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OUTLINES

OF

ELEMENTARY BOTANY.

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ELEMENTARY BOTANY.

A MANUAL FOR YOUNG STUDENTS.

BY

ALEXANDER SILVER, M.A., M.D.

PHYSICIAN TO CHARING CROSS HOSPITAL,
AND LECTURER ON PHYSIOLOGY IN CHARING CROSS HOSPITAL SCHOOL
OF MEDICINE,
FORMERLY LECTURER ON BOTANY AT THE CHARING CROSS AND
LONDON HOSPITALS.

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TO

DAVID JOHNSTON, ESQ., M.A., M.D.,

OF KAIR HOUSE, KINCARDINESHIRE,

THE AUTHOR'S EARLIEST INSTRUCTOR IN PRACTICAL MEDICINE,

AS A MARK OF

PROFOUND RESPECT FOR HIM AS A MAN,

AND OF GRATITUDE FOR HIS UNFAILING KINDNESS,

THIS LITTLE WORK

Is Dedicated

BY

THE AUTHOR.

PREFACE.

In bringing out a new edition of this little work, the author has chiefly been animated by a desire to embody in a simple form the many new facts which have of late years been added to vegetable physiology. Every part of the book has been carefully revised, and many new woodcuts added; but the most material alterations will be found in connexion with the physiological part, and that relating to classification. The latter has been much abridged, so that though a good deal of new matter has been added, the size of the book has been hardly, if at all, increased.

Almost all the new woodcuts have been obtained—as were many of the old ones—from the publishers of M. Payer's beautiful "Eléments de Botanique," a book but little known in this country. There is no division of natural science where good illustrations are so useful as in botany, and as far as is compatible with cheapness, they cannot be too numerous. It has been with this idea, and with the desire of enlisting the sympathies of young students, that the additions have been made to the illustrations in this volume. Botany should, if possible, be studied at school, or at all events before the medical student has entered on his strictly professional work; and it is to this class these illustrations are most useful. This little manual is in no way intended to supersede larger and more important text books. It is only an introduction to botanical science. To those desirous of extending their studies in physiological botany more especially, the author would strongly recommend Sach's "Text Book of Botany," now obtainable in an English dress.

LONDON: *November*, 1876.

OUTLINES
OF
ELEMENTARY BOTANY.

INTRODUCTION.

BOTANY is *that department of natural science which treats of plants in all their relations.* Seeing, then, that Botany deals with plants and plants only, the question which has to be settled first of all is, "What is a plant?" Like many other questions, this is far more easily propounded than answered. In fact, no definition can be given which will include every vegetable and exclude every animal, for, though the distinctions between the higher divisions of the animal and vegetable kingdoms are numerous and well-defined, it is not so in the case of those organisms which are the lowest representatives of these two kingdoms, and which have been by some erected into a separate group termed the Protista. Seeing, then, that no very exact definition can be given, the short and concise way in which Linnæus stated the distinctions between the three grand divisions of Nature, will serve as well as a more elaborate and less easily remembered statement. He (Linnæus) phrased the differences between the mineral, vegetable, and animal kingdoms very much as follows:—

MINERALS GROW.
PLANTS GROW AND LIVE.
ANIMALS GROW, LIVE, AND FEEL.

As the relations of plants are numerous and extensive, it is usual to divide the study of them into several parts; in other words, Botany is subdivided into various branches, which *it is advisable to* treat separately. These subdivisions are (1) *Morphology,* (2) *Physiology and Physiological Anatomy,* (3) *Nosology or Pathology,* (4) *Systematic Botany,* (5) *Geographical Botany and Palæontological Botany.*

1. MORPHOLOGY is that department of Botany which treats of the *outward forms* of plants. It may be subdivided into the Morphology of *Flowering* (Phanerogamic) and of *Flowerless* (Cryptogamic) plants.

2. PHYSIOLOGICAL ANATOMY and PHYSIOLOGY comprehend all that relates to the *minute structure* and *functions* of plants, and is also usually made to include the—

3. NOSOLOGY or PATHOLOGY of plants, which treats of their diseases and their structure when diseased.

4. SYSTEMATIC BOTANY is that part which treats of the arrangement of plants into groups, characterised by the possession or absence of some particular point or points, and is of two kinds—viz., (1st) that which seeks to classify plants by any *one* character, however carefully selected, and (2nd) that which seeks to group plants by the *sum* of their characters, and not by any one of them. The former is known as the *artificial,* the latter as the *natural* systems of classification.

5. GEOGRAPHICAL BOTANY and PALÆONTOLOGICAL BOTANY are usually treated of together; the former takes cognizance of the *distribution of plants in space*—*i.e.,* over the surface of the globe; the latter, of their *distribution in time,* that is, in the various strata of the earth's crust.

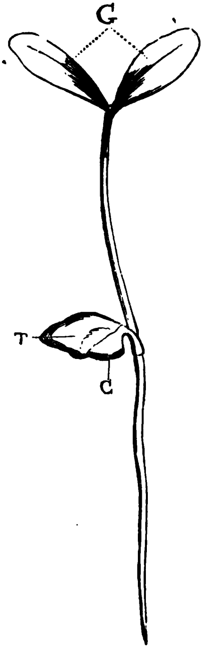
These various subjects will be discussed in the order above indicated, beginning with VEGETABLE MORPHOLOGY.

PART I.

SECTION I.

MORPHOLOGY OF PHANEROGAMIA.

FIG. 1.

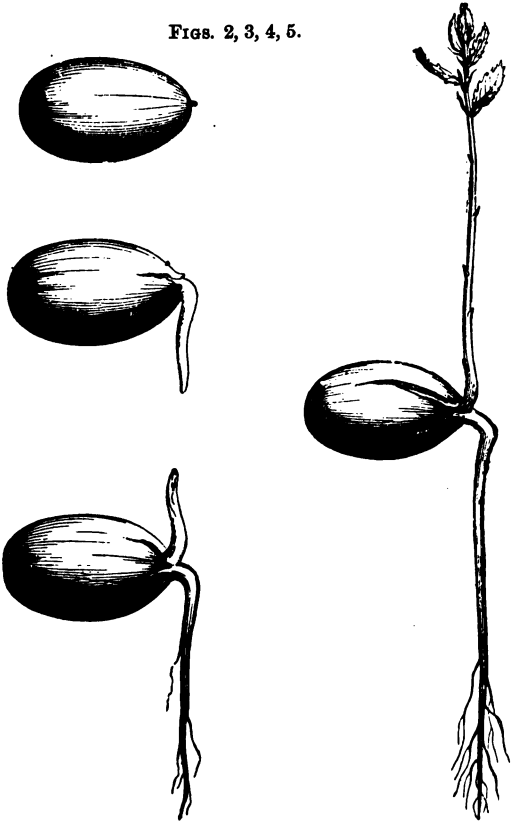


Germinating seed of orange, (Dicotyledon.) G, Plumule; C, Cotyledons; T, Tigellus.

If a seed, such as a pea, bean, or acorn, be placed in damp soil, and kept at a moderate temperature, it soon begins to swell. By-and-by, a small protrusion is seen, which soon becomes distinguishable into two well-marked divisions, of which one always tends to grow upwards towards the light and air; the other sinks deeper in the earth, and shuns the light. To the part which grows upwards are attached two organs more or less leaf-like, which, in some cases, ultimately become leaves. In this germinating seed all the parts of the plant are shadowed forth, for every organ belonging to the mature plant is only a modification of one or other of the parts of this embryo.

That part which grows upwards is terminated by a little bud; it is called the PLUMULE and becomes the stem. The part which grows downwards usually produces the roots, and is called the RADICLE. The part where these two are joined to each other is *called the* TIGELLUS, or Collar, while the lateral organs receive the name of Cotyledons. (See Figs. 1, 2, 3, 4, 5.)

Figs. 2, 3, 4, 5.



Germination of an acorn, showing the development of the radicle and plumule. This readily takes place when an acorn is placed in water. Such young plants suspended in a hyacinth glass form beautiful table ornaments.

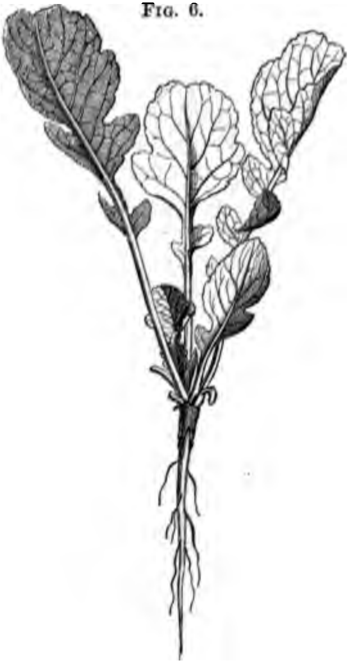
The Root, or portion of the plant developed from the *radicle, will be best* described first.

CHAPTER I.

THE ROOT.

THE root may be defined as *the descending axis of the plant, which usually penetrates the ground, to fix the plant and absorb nourishment already in a fluid state.* To this definition there are certain objections,—for instance, in plants hanging from the roofs of caves, the roots ascend instead of descending. Again, in aerial and aquatic plants

FIG. 6.

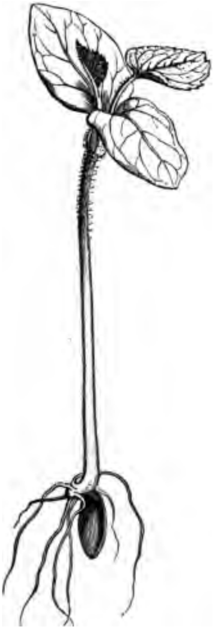


Axial Root (Turnip).

the roots may not reach the ground, and in that case, they cannot abstract nourishment from it. These objections, however, have very little weight, being merely technical.

Roots developed from the radicle are termed AXIAL or TRUE roots; all others are classed together as ADVENTITIOUS roots. The former (*axial*) are found in plants having two seed-lobes, and hence termed *Dicotyledons*, or, from the structure of their stems, Exogens. In such plants as have but one seed-lobe (*Monocotyledons*), and have that peculiar kind of stem called Endogenous, *adventitious roots* alone occur.

FIG. 7.



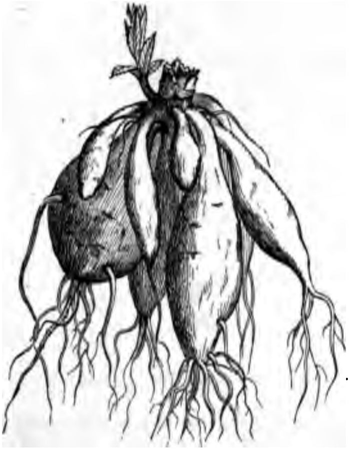
Multiple roots of the young Melon (Dicotyledon), seed attached.

The axial roots of Dicotyledons appear to branch by a kind of bifurcation of the growing point. When one central part maintains a distinct superiority over all the other divisions, so as to seem a continuation of the stem, it constitutes that form of root seen in the carrot, and called a TAP *root*. On the other hand, should the branches of the radicle be numerous, and nearly all of the same size, the root is said to be FIBROUS; such roots occur, most frequently, in plants growing in light sandy soil.

In herbaceous plants, the tap-root often becomes a reservoir of nourishment, for the use of the plant when it flowers, and is extensively used for food. It must, however, be borne in mind, that, in the opinion of some botanists, these succulent tap-roots are only underground stems, and the rootlets projecting from them are the proper roots. As examples of such roots, there may be mentioned the carrot, which is called a *fusiform* (spindle-shaped) tap-root; the radish, which being thickest in the middle, is called a *double fusiform* tap-root; and the turnip, which is called a *napiform* tap-root.

The roots of Monocotyledons, of the higher flowerless

FIG. 8.

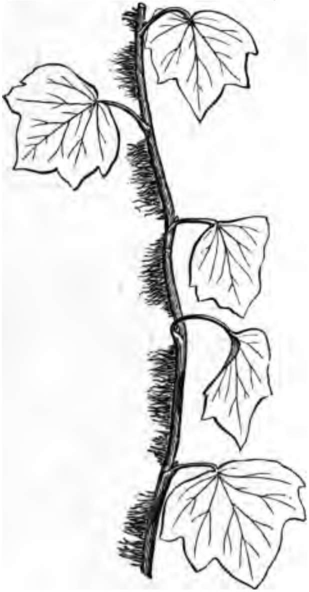


Tuberous roots (Dahlia).

plants (Cryptogams), and of such Dicotyledons as are not raised from the seed, are always ADVENTITIOUS. Those of the two first groups branch by the development of new adventitious roots; those of the last bifurcate in the same way as the axial roots of the same class; but on this point all authorities are not agreed.

As with axial roots there are two great divisions, so there are two of adventitious roots. Those corresponding with the tap-root of the carrot, and produced by thickening of some of the branches, are called *tuberous*, and contain a store of nourishment for the future use of the plant—ex. Dahlia (*Fig. 8*). The adventitious roots of palms are woody.

FIG. 9.



Aerial adventitious roots (Ivy).

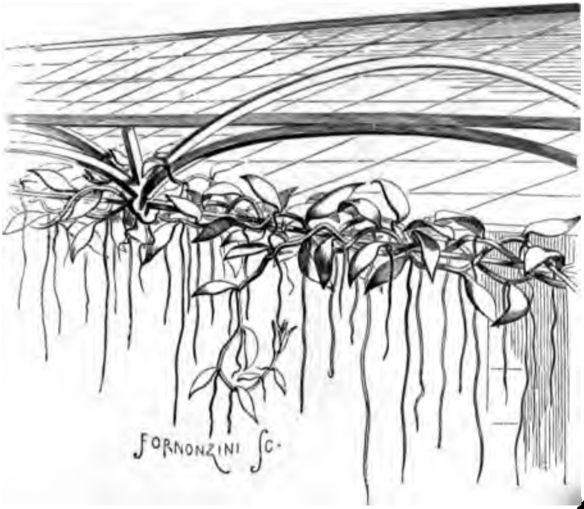
The other variety of root is the Fibrous, and is seen at the bases of lilies, onions, &c. (Fig. 14). A mixture of these two forms, called a *Fasciculate* root, is seen in Ranunculus ficaria.

There are some peculiar modifications of roots which have obtained special names, as the *coralline* root, resembling in shape a coral necklace. This occurs in an orchid, hence called *Corallorhiza.*

When there are alternate expansions and contractions on the divisions of the root, the swellings being a little apart, the root is called a *moniliform* root, but if close together an *annular* root, as in Ipecacuanha; while if at irregular intervals the root is said to be *nodulose*, or *nodose* (ex. Spiræa filipendula). When a tap-root is twisted, instead of being straight, it is said to be *contorted;* when it ends abruptly, it is said to be *premorse* or *bitten-off.*

Aerial roots are seen in the mangrove, where they are axial; in the ivy (Fig. 9), the vanilla plant (Fig. 10), and in

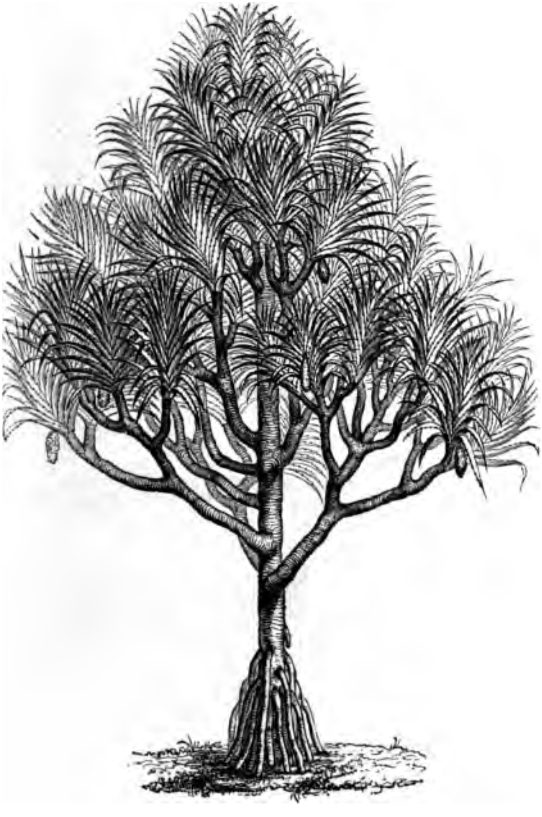
Fig. 10.


FORNONZINI SC.

Aerial roots of the Vanilla Plant.

the banyan tree, where they are adventitious. In the Pandanus (Fig. 11) or Screw Pine, they appear to support the *tree on stilts,* and they also occur in tree-ferns. In the *Dodder, the original* root decays when the plant has been

FIG. 11.

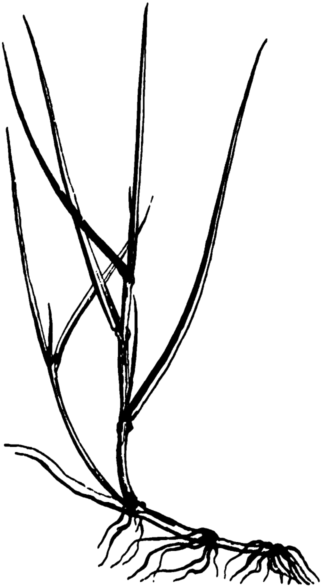


Pandanus or Screw Pine.

able to graft itself on to another, or nurse plant, from which it afterwards draws its nourishment.

AQUATIC ROOTS are found in such plants as the duckweed, where they are floating; and in the water ranunculus, where they pierce the soil.

FIG. 12.



Creeping Stem with primary and secondary adventitious roots.

In most cases, *roots* may be distinguished from *root-stocks* or *rhizomes*, which they closely resemble, by not producing leaves or buds, but additional particulars on this point will be given when discussing the structure of roots.

OFFICINAL ROOTS.

Calumba—dried root (sliced) of Cocculus palmatus	Tonic.
Pareira—dried root of Cissampelos Pareira	Tonic and Diuretic.
Armoracia—recent root of Cochlearia Armoracia (Horseradish)	Stimulant and Tonic.
Senega—dried root of Polygala Senega	Expectorant.
Krameria—dried root of Krameria Triandra (Rhatany)—act. prin. Tannin, &c.	Astringent.
Glycirrhiza—recent and dried root or rhizome of Glycirrhiza glabra	Demulcent.
Ipecacuanha—dried root of Cephaelis Ipecacuanha (act. prin. Emetine)	Emetic, Sedative, Diaphoretic.
Taraxacum—recent root (rather rhizome) of Taraxacum Dens Leonis	Alterative and Tonic.
Gentiana—dried root of Gentiana lutea	Tonic.
Radix Scammoniæ—dried root of Convolvulus Scammonia	Purgative.
Jalapa—root tuber of Exogonium purga	Purgative.
Rheum—dried root of various species of Rheum	Astringent, Tonic, Purgative.
Sassafras—dried root of Sassafras officinale	Stimulant and Diaphoretic.
Serpentaria—dried root of Aristolochia Serpentaria	Stimulant and Tonic.
Sarsa—dried root of Smilax Officinalis (Sarsaparilla)	Alterative, Diaphoretic, &c.
Radix Granati—bark of the root of Punica Granatum (Pomegranate)	Anthelmintic.
Valeriana—root (dried) of Valeriana officinalis (act. prin. Valerianic Acid)	Antispasmodic.
Arnica—root of Arnica montana	Stimulant and Irritant.
Hemidesmus—root of Hemidesmus Indicus	Alterative and Tonic.
Radix Belladonnæ—dried root of Atropa Belladonna (act. prin. Atropia)	Sedative.
Radix Aconiti—dried root of Aconitum Napellus (act. prin. Aconitia)	Sedative.

NON-OFFICINAL ROOTS AND FORMERLY OFFICINAL ROOTS USED IN MEDICINE.

Helleborus—dried root and rhizome of Helleborus niger	Purgative.
Actæa—dried root of Cimicifuga or Actæa racemosa	Stimulant, Antispasmodic, &c.
Althæa—dried root of Althæa officinalis *(Marshmallow)*	Demulcent.

Tormentilla—dried root or rhizome of Potentilla Tormentilla	Astringent.
Carota—recent root of Daucus Carota...	Demulcent.
Sumbul—Musk root, source unknown...	Stimulant and Antispasmodic.
Inula--root of Inula Helenium (Elecampane)	Stimulant, &c.
Pyrethrum—root of Anacyclus Pyrethrum (Pellitory)	Sialogogue.
Spigelia—root of Spigelia Marilandica (Caroline Pink)	Anthelmintic.

CHAPTER II.

THE STEM.

THAT part of the embryo which grows upwards, seeking the light, and having appendicular organs or leaves attached, is called the *plumule*, and the developed plumule becomes the *stem*. The plumule is terminated by a bud, on which the elongation of the stem depends. This is called the TERMINAL BUD, and in such plants as do not branch (palms, &c.) there are no others. The branching of a stem depends on the formation of buds on the sides of the plant, which originating in the angle between the leaf and the stem (the AXILLA) are called AXILLARY BUDS.

That part of the stem where a leaf originates, from having the tissues mixed up in a peculiar manner, is called a NODE, and the space between any two of these is termed an INTERNODE, so that the whole stem is made up of these two—nodes and internodes. In most plants the leaves are at some distance from each other vertically, in which case the internodes are said to be *developed;* where, however, the leaves rise close to each other, as they do in buds, in bulbs, &c., the internodes are said to be *undeveloped*, or *but little developed*, according to their degree of closeness. From this it is evident that the elongation of a stem is mostly due to development of its internodes; whilst a shortened or abortive condition of stem is due to their non-development.

If a stem be examined after it has attained a considerable size, it will be found that its appendages vary in appearance according to their position. At the lower part of the stem, where it is covered by the earth, if it have any kind of appendage at all, such will be in the form of *scales*. Hence this region of the stem is called the LEAF-SCALE REGION.

In the central part of the stem again, the lateral organs take the form of fully developed *leaves* often bearing *leaf-buds* in their axils. This is the typical region of the stem, and is called the LEAF REGION.

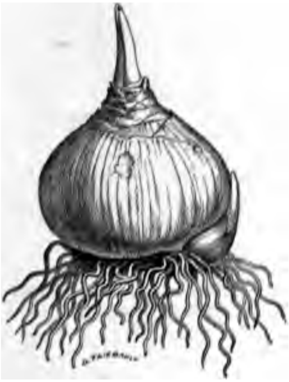
In the upper part of the plant the leaves are often *modified in shape* and colour, and bear in their axils buds, which, in course of time, develop flowers instead of leaves. Such appendages are called *Bracts*, and the part characterised by them is called the FLOWER LEAF, OR BRACT REGION.

All these regions may not be represented in one and the same plant. For descriptive purposes the regions of the stem and all kinds of stems themselves may be divided into Underground and Aerial. The former are characterised by *leaf scales*, the latter by *leaves* and *bracts*.

A. Underground Stems.

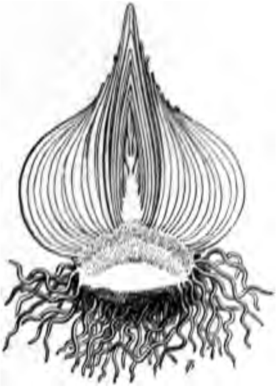
The variety of stem whose typical appendages are leaf-scales occurs most frequently in herbaceous, perennial plants. It is usually in part at least subterranean, and its roots are generally adventitious. According to the manner in which they are constituted, and according to their mode of development, underground stems are grouped, as Bulbs, Corms, Rhizomes, or Rootstocks, and

Fig. 13.



Tunicated bulb of Hyacinth.

Fig. 14.

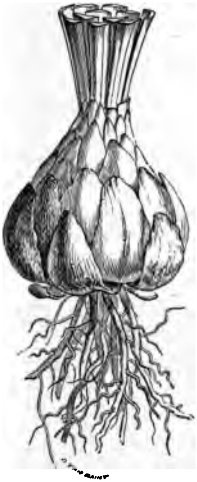


Vertical section of a bulb of Hyacinth, showing the solid portion or stem, leaf-scales, and fibrous roots.

Tubers. Most of these contain large quantities of starch or other nourishment for the future use of the plant, and which are useful as food. In some cases peculiar products render these useful in medicine and the arts.

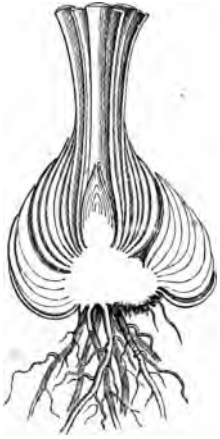
1. A BULB may be defined as *an underground stem, remaining permanently in the condition of a bud.* The greater part of it is made up of leaf-scales, the stem proper being represented by the small solid portion at the base. According as the scales *completely* or only *partially* surround the bulb, varieties known as *tunicated* (as in the onion and hyacinth) and *squamous* or *scaly* bulbs (as in the lily) are produced.

FIG. 15.



Scaly bulb of Lily.

FIG. 16.



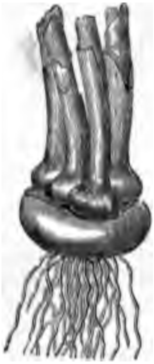
Section of the same bulb, with solid stem and leaf scales.

The only officinal bulb is the

Urginea Scilla (Squill), act. prin. unknown	Expectorant, diuretic, emetic.

2. The CORM very closely resembles the bulb in its appearance, but differs in its constitution. It is sometimes called a *solid bulb.* Instead of being chiefly made up of *leaf-scales,* it is mainly composed of a *thickened stem with slightly developed internodes surmounted by a bud.* In the bulb, the *greater part* consists of fleshy scales, only a small part being

FIG. 17.



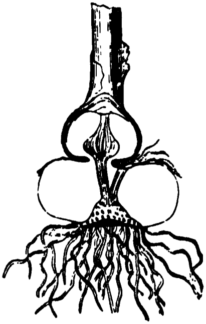
Corm (Crocus).

solid stem. In the corm the reverse is the case, the greater part being composed of solid stem, leaf-scales holding a secondary place.

The only officinal corm is that of

Colchicum Autumnale (Meadow Saffron), act. prin. colchicia	Stimulant to bowels and kidneys; used in gout and rheumatism.

FIG. 18.

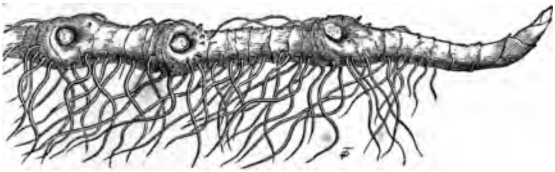


Perpendicular section of the Corm of the Crocus.

3. The RHIZOME, or ROOT-STOCK, very closely resembles a root, for which it is often mistaken; it may, however, be distinguished by its possessing the power of producing leaf-buds. It might be defined as *an underground stem, with its internodes but little developed, growing in a linear direction at one extremity, while it dies away at the other.* More loosely, it might be said to be *a series of permanently connected corms developing in a linear manner.* From the corm it differs chiefly in its mode of development, for while in the corm the new corm is produced as a bud, in the axil of the leaf-scale, and becomes isolated by the decay of the old corm in the centre—in the rhizome the old and new parts remain permanently connected—it grows at one end, while it dies at the other. The former may be said to develop *centrifugally*, the latter *linearly*.

A kind of rhizome, which occurs in grassy plants, growing in light soil, is known as a SOBOLES, or CREEPING STEM—a good example is the *Carex arenaria*, so common on sandy hillocks near the sea. Many of the so-called medicinal roots are really rhizomes. The officinal rhizomes are—

FIG. 19.



Rhizome (Solomon's Seal).

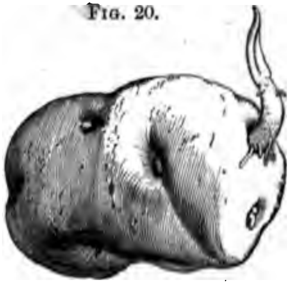
Podophyllum—dried rhizome of Podophyllum peltatum, act. prin. Resina Podophylli	Cholagogue, Purgative.
Zingiber—dried rhizome of Zingiber officinale	Stimulant.
Filix—rhizome of Aspidium Filix mas...	Anthelmintic.
Curcuma—rhizome of Curcuma longa (Turmeric)	Stimulant and Colouring Agent.

FORMERLY OFFICINAL.

Tormentilla—dried root or root-stock of *Potentilla Tormentilla*	Astringent.
Veratrum rhizome of Veratrum album	Purgative and Rubefacient.

4. The TUBER is commonly formed of a greatly thickened portion of a branch given off in the axil of a leaf-scale.

FIG. 20.



Tuber (Potato), showing buds in the form of eyes.

It has buds in the form of eyes, capable of producing independent stems. The best known examples are the potato (Figs. 20 and 21) and artichoke.

B. AERIAL STEMS.

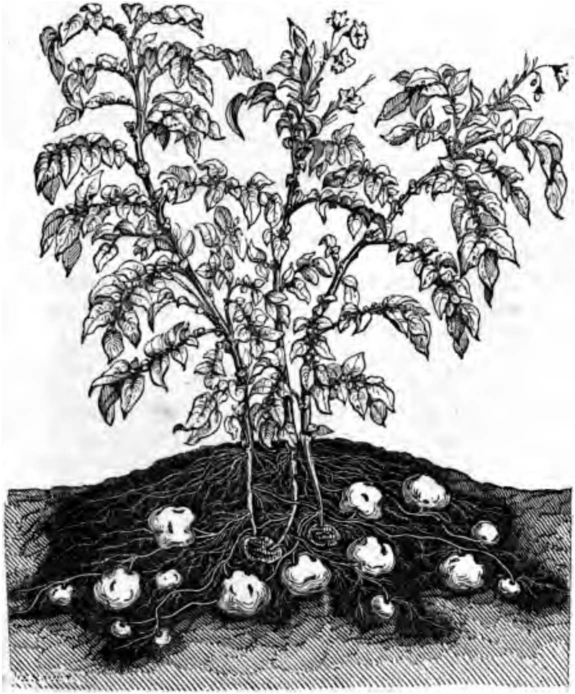
The next part of the stem to be considered is that characterised by leafy appendages, and which is usually known as the stem proper. The appearance of aerial stems will vary with, 1st, the development of their internodes; 2ndly, their branching (Fig. 22), which will in turn depend on the arrangement of their leaves; and 3rdly, on their consistence. They are most easily grouped by the last peculiarity, and are divided into HERBACEOUS (Fig. 23) and WOODY STEMS.

In most cases, there is enough woody tissue produced to enable plants to stand upright. Such stems are said to be ERECT, of which kind all our forest trees are instances.

Sometimes the consistence is not sufficient to enable the plant to preserve an erect position, except at its extremity, while the remainder rests on [illegible] ground; such a stem is said to be PROCUMBENT (Fig. 24), or DECUMBENT, or ASCENDING; the first of these indicating the greatest amount of flatness (example, thyme). Should *such a stem send out* adventitious roots at interv[illegible] a new variety known as the CREEPING (repent) stem (Fig. 25) is produced, as is seen in Ranunculus repens.

Some plants, though not strong enough to keep themselves erect by their own consistence, nevertheless contrive to rise by clinging to larger plants or other objects. *According to their* plan of doing this, they are divided *into* CLIMBING *and* TWINING. Climbing stems raise them-

FIG. 21.

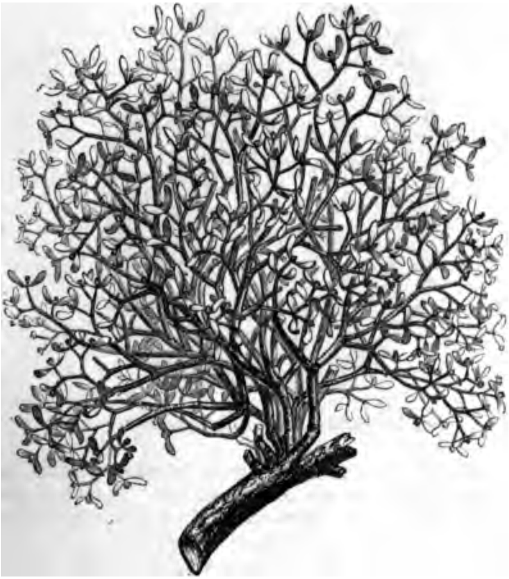


Growing Potato, showing the formation of tubers from thickened portions of underground branches.

selves by *tendrils*, as in the pea, vine, &c.; by *adventitious roots*, as in the ivy; by *suckers*, as in the dodder, or by their *leaf-stalks*, as in clematis.

TWINING STEMS support themselves by twisting round the objects to which they are attached either from left to right, as in the French bean, or from right to left, as in the hop. The former are said to be *dextrorse* (Fig. 26), the latter *sinistrorse*, following the same movement as in throwing a plaid over the left shoulder.

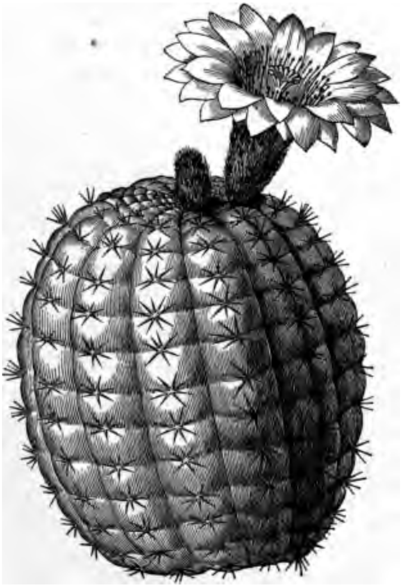
FIG. 22.



Dichotomous branches of the Mistletoe.

As herbaceous stems have not sufficient woody matter to enable *them to* survive the colds of winter, they sometimes *have the earth* instead of wood as a protection; in

FIG. 23.

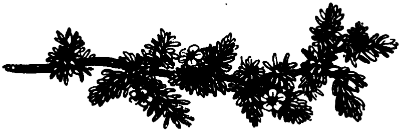


Herbaceous stem of Echinocactus.

other words, their principal part is underground, and may, by that means, become perennial. The stem peculiar to grasses is called a *culmus*, other herbaceous stems being designated by the term *caulis*.

WOODY STEMS, again, are seen only in plants destined

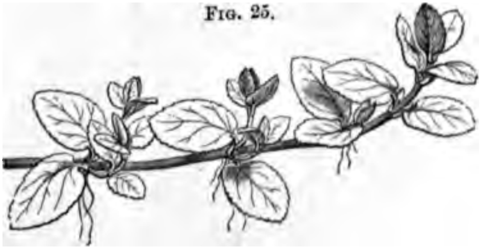
FIG. 24.



Procumbent or trailing stem.

for a somewhat prolonged existence, and are divided, according to their mode of branching, into *trunks* and *stocks*. Should the stem give off branches at various elevations, it would be called a TRUNK (truncus); whereas were the branches and the leaves confined to the summit, it would be called a STOCK (caudex.) The former is exemplified in most of our forest trees, the latter in the palms. Some very curious modifications of stems are seen in the Cactaceæ and tropical climbers.

FIG. 25.



Creeping stem of Veronica.

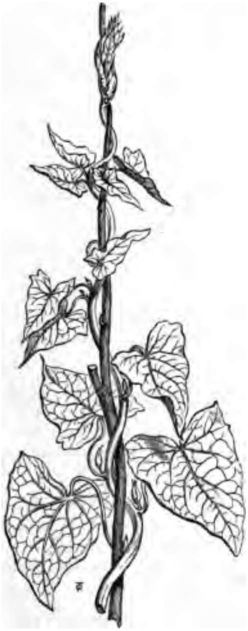
Repetitions of the Axis.

In the angles formed by the leaves with the stem, are found the *leaf-buds*, which by their development produce *branches*. These may be called *repetitions of the axis.* Usually only one bud springs from the axil of a leaf, but sometimes, as in the Honeysuckle (Lonicera), several may be seen at one time in a single axil.

As long as a plant continues to grow it is terminated by a bud, differing from axillary buds only in position. The terminal bud is the continuation of the plumule, whereas axillary buds originate as small cellular projections, in the acute angles formed by leaves with the axis. In course of time these become identical in structure with the main axis, to which they are attached, and from which they originate. The *secondary axes* thus produced are called *branches* (rami), and the disposition of the branches of a plant is termed its RAMIFICATIONS.

The main axis, then, is developed from the plumule or terminal bud of the embryo, while branches or secondary axes originate from axillary buds growing from the main axes. These buds or secondary axes, as well as the terminal bud, consist of a rudimentary stem with its internodes undeveloped, and having rudimentary leaves attached to it. The whole is usually covered, especially in winter and early spring, with hardened scales, for the protection of the tender parts within. Should no lateral buds be produced on a plant, or should those produced not develop into branches, as is the case in palms, the stem, as already explained, is *called a stock* or *caudex.* If lateral buds develop into *branches, whilst the* central stem maintains a decided

FIG. 26.

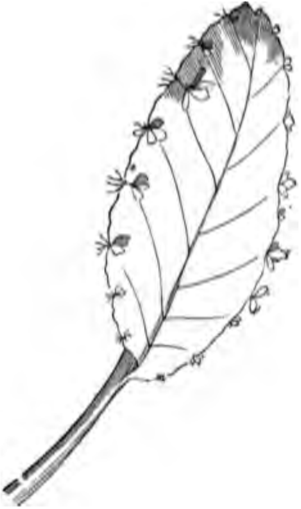


Convolvulus stem, turning from left to right (dextrorse).

superiority over all its repetitions, and it attains a considerable height, such a plant is called a TREE (arbor.) Where there is no distinct central axis, or where the plant is of small size, though woody, it is called a SHRUB (dumes).

All axillary buds do not develop into branches, and sometimes they prove abortive in a regular order. For instance, in some pines all the buds remain undeveloped for a certain interval, beyond which a number of branches rise so close together as to appear very like a whorl. The buds which remain undeveloped, retain their vitality. At the same time they become *dormant* or *latent*, so that should at any time the ordinary buds be destroyed, as happens when a tree is partially cut down, or the buds are destroyed by frost, they give rise to new axes, springing from apparently abnormal situations, for at that time there *are no leaves in* the axils of which they coul *be developed. It also* happens occasionally, that bu

FIG. 27.



Leaf of Bryophyllum producing buds at its edges.

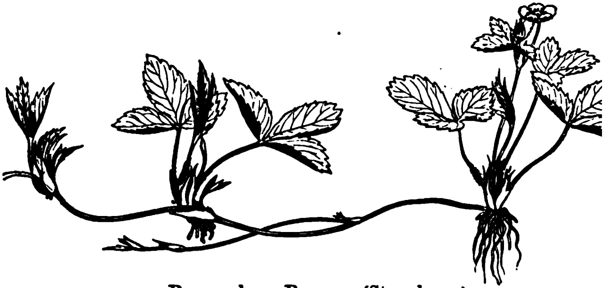
arise in parts which do not usually produce them, as i roots, edges of leaves (Fig. 27), &c. Both of these kind are called ADVENTITIOUS. Some plants may even be propagated by cuttings from their roots.

When more than one bud is developed in the axil of leaf, one is looked upon as the normal axillary bud, whil the additional ones, as in the Honeysuckle, are said to b ACCESSORY. Occasionally, several of these axillary bud may be developed in a mass, as in pines, giving rise t what are called FASCIATED BRANCHES.

Modified Repetitions of the Axis.

The forms that have just been described are commo enough, but some special modifications not so often seen

FIG. 28.



Propagula or Runners (Strawberry).

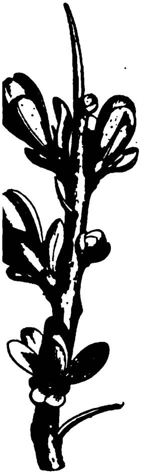
have yet to be mentioned. In the Strawberry, long an slender branches are produced in spring, which stretc out till they touch the earth, and at that point produc adventitious roots and leaves, in short, a new plant, whic in its turn repeats the process. Such a branch is calle a FLAGELLUM or RUNNER (Fig. 28). A short and thic variety of runner called a PROPAGULUM or OFFSET, is see in the Houseleek (Sempervivum). This connexion o the new plant with the parent stem may only be kept u till the former can support itself, after which the runne or offset may gradually disappear.

If, instead of creeping along the surface of the ground *the new axis,* though rising at some height above th ground, bend downwards till it can take root, as is sometimes seen in the *Currant* and *Gooseberry*, it will be termed a *stolon*. On the other hand, if the new axis originate from that part of the stem which is under ground, and in that situation be partially developed, so as to rise above the surface at some distance from the parent, as now and then happens in the *Raspberry*, *Rose*, and *Mint*, such a secondary axis is called a SUCKER (SURCULUM), and the plant producing it is said to be SURCULOSE. When the part which rises above ground is thick and fleshy, as in the Asparagus when fit for eating, t is called a TURIO.

The process of causing branches to take root and so produce new plants, may be imitated artificially, and is hen called LAYERING when the branch is not separated rom the stem at once; PROPAGATION BY CUTTINGS OR SLIPS, when it is so separated.

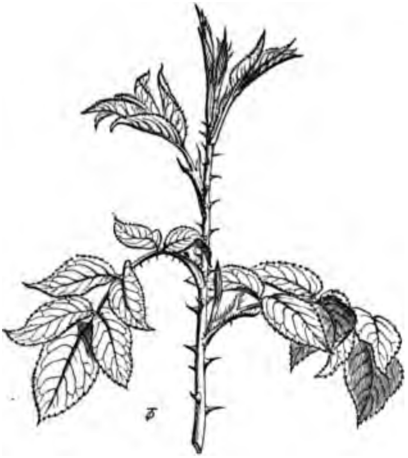
SPINES.—Besides these modifications of the secondary xes, a few yet remain to be described. It sometimes

FIG. 29.



anch ending in a *spine.*

FIG. 30.

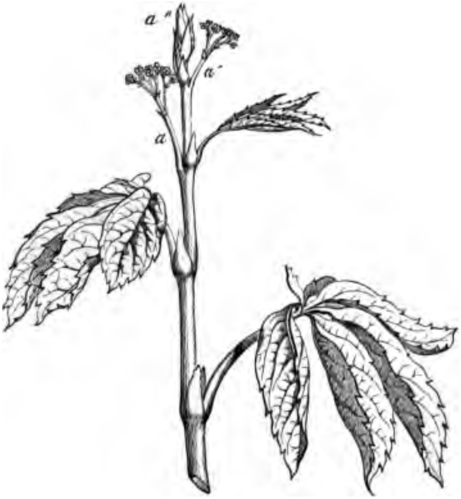


Rose branch showing prickles.

happens that an axillary bud becomes elongated to certain extent, after which the leaves fall off, and the a becomes greatly hardened. Such a modified branch termed a SPINE (Fig. 29). These modified branches m not be confounded with the *prickles* seen on the bark the rose tree (Fig. 30), which are mere epidermal pendages containing no true woody tissue; nor with THORNS which are developed on the edges of leaves, & as in the holly. As examples of spines, may be cited t *Blackthorn*, and the principal spines of the *Furze* (*Ul* in which, however, the leaves are thorny also.

TENDRILS.—Some of the plants which raise themsel by means of sorrounding objects do so by clinging

FIG. 31.

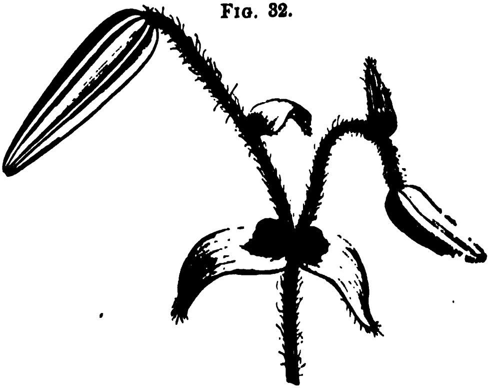


Pseudo-stem of the Vine. ***a***, **Termination of first axis.** ***a'***, **Termination of second.** ***a''***, **Termination of third.**

them by *tendrils* (cirrhi), which are in some cases m *fied branches* devoid of leaves (see Modified Leaves). S *tendrils occur* in the Passion-flower (Passiflora), an *the Vine.* In the latter case, however, the tendrils primary rather than secondary axes; and the stem consists of a number of secondary axes so arranged as to seem continuous (Fig. 31).

All buds, save the terminal one, being only immature secondary axes, the purpose served by their connexion with the primary axis is merely for their nourishment. Should, therefore, a bud by any means be enabled to support itself apart from the parent stem, it may be separated, and in this way there can be produced a new plant. Sometimes it happens that a leaf-bud becomes enlarged and succulent, in fact, becomes an aerial bulb, as in the Lilium bulbiferum (Fig. 32). Such secondary axes are capable of maintaining a separate existence, and the plant may be propagated by them. The plants so produced must, however, be looked upon as mere repetitions of the individual—since, for the propagation of the species, *special buds* are set apart and fitted for their peculiar functions by various processes to be described hereafter. Such buds are called SEEDS. Some of the underground stems, more especially the *tuber*, should be described under this head, as being modified branches; but it was *preferable* to describe them all together.

FIG. 32.



Lilium bulbiferum, showing aerial bulbs or enlarged axillary buds.

OFFICINAL STEMS, ETC.—ENTIRE PLANT OFFICINAL.

Chirata—entire plant of Ophelia Chirata, dried	Tonic.
Lobelia—entire plant of Lobelia inflata, dried	Sedative and Antispasmodi

FORMERLY OFFICINAL.

Lactuca—flowering plant of Lactuca sativa (Lettuce)	Sedative.

WOOD.

Guaiaci Lignum—wood of Guaiacum officinale	Stimulant, Alterative, ar Diaphoretic.
Quassia—wood of Picræna excelsa	Tonic.
Pterocarpus—wood of Pterocarpus Santalinus (Sandal-wood)	Colouring agent.
Hæmatoxylum—heart-wood of Hæmatoxylum Campeachianum	Astringent.
Dulcamara—young branches of Solanum Dulcamara	Alterative.
Acacia Catechu—wood yields an extract (Catechu)	Astringent.

BARKS.

Cusparia—bark of Galipea Cusparia (Angostura bark-tree)	Tonic and Antiperiodic.
Cinchona Flava—bark of Cinchona Calisaya, act. prin. Quina	All Tonic and Antiperiodi
Cinchona Rubra—bark of Cinchona Succirubra, act. prin. Cinchonia and Quina	
Cinchona Pallida—bark of Cinchona Condaminea, act. prin. Cinchonia	
Cinnamomum—bark (inner) of shoots of Cinnamomum Zeylanicum	Stimulant and Carminativ
Nectandra—bark of Nectandra Rodiæi (Bebeeru-tree)	Tonic and Antiperiodic.
Mezereum—bark of Daphne Mezereum	Alterative.
Cascarilla—bark of Croton Eleuteria	Stimulant and Tonic.
Quercus—bark of small stems of Quercus *pedunculata*	Astringent.
Ulmus—the inner bark (dried) of Ulmus *campestris*	Tonic and Astringent.

FORMERLY NON-OFFICINAL BARKS USED IN MEDICINE.

Cortex Winteri— bark of Drymis Winteri	Aromatic Tonic.
Canella—bark of Canella alba	Aromatic Tonic.
Simaruba—bark of Simaruba amara	Tonic.
Cortex Salicis—bark of Salix caprea (Willow)	Tonic and Antiperiodic.

OFFICINAL TOPS, ETC., OF PLANTS.

Aconitum—fresh leaves and flowering tops of Aconitum Napellus	Sedative.
Scoparius—tops (fresh and dried) of Sarothamnus Scoparius	Diuretic.
Sabina—fresh and dried tops of Juniperus Sabina	Local Irritant & Stimulant.
Cannabis Indica—flowering tops of Cannabis Sativa	Sedative & Antispasmodic.
Hyoscyamus—fresh and dried leaves and young branches of Hyoscyamus niger, act. prin. Hyoscyamia	Sedative.
Conium—fresh leaves and branches of Conium maculatum, act. prin. Conia	Sedative, &c.

PECULIAR.

Galla—excrescences caused by an insect on the small twigs of Quercus infectoria, contain Tannin, &c.	Astringent.

CHAPTER III.

THE LEAF.

Every one knows what a leaf is, but it is not so easy to define it. It may be called the "*typical appendage of the stem*," but that conveys no very definite idea. It might also be described as a flattened lateral expansion of the plant, but the onion has rounded leaves. The great distinction laid down by Schleiden between stems and leaves is, that whereas stems are unlimited as to their growth, leaves are strictly limited. None of these definitions is entirely satisfactory.

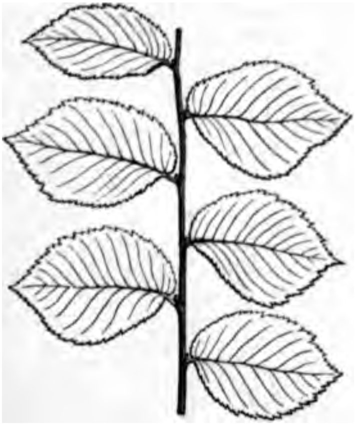
The leaf being the typical appendage of the stem every other appendage must be referred to its type, just as the bud is the type of the axis itself in all its repetitions.

Though leaves originate from the sides of the stem they do not occur at random, but according to certain laws, which vary in different plants. These laws, and the study of them, are known by the name of Phyllotaxy.

There are two grand types in the arrangement of leaves. In the one, *no two leaves* rise at the same level; in the other, *two or more leaves* originate on a level with each other. The former, where only one leaf rises from each node, is known as the alternate or scattered type. Where, again, two leaves originate from each node—or rather, where two nodes coincide in point of elevation—the leaves are said to be opposite. When more than two leaves arise at one point, the leaves are said to be verticillate, or whorled; the whole collection of leaves rising at that level being called a Verticil, or Whorl.

Alternate Type.—It sometimes happens that the leaves are so arranged that there are only two perpendicular rows of them on the plant (Fig. 33), these rows being exactly opposite to each other, and therefore separated by the whole diameter of the stem. Where such is the case, if, beginning with any one leaf, a string be tied to it, and be made to pass round the leaf next in order, *above the starting* point, which will be on the opposite *side, and to* end with the one which is immediately

FIG. 33.



Alternate leaves. ½ or distichous arrangement.

above the first, this last leaf will be found to be the third to which the string is attached, taking the leaves in order from the one from which the string started; it will also be found that the string has passed completely round the stem *once*, and that it has done so in a spiral direction (Fig. 34).

All this may be indicated on a very simple plan. The number of times the string has passed round the stem is made the numerator of a fraction, while the number of leaves passed on the way serves as the denominator of the same. In the case just described the number of turns round the stem was one, while the number of leaves passed was two, so that the fraction will be ½; and the arrangement is so designated. These fractions serve to indicate more, however, than would at first sight appear. Thus, by adding *one* to the denominator, the number of the leaf immediately above the first or *starting leaf, can be ascertained*. This

FIG. 34.

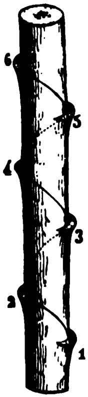
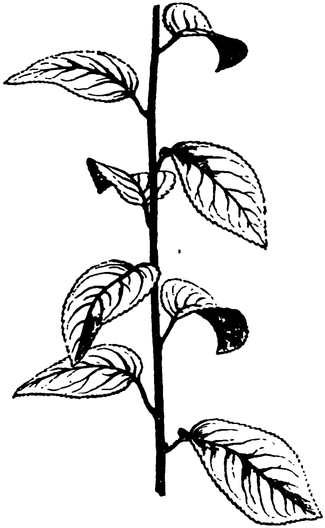


Diagram of ½ arrangement.

in the instance just given is 3, or the third leaf in the spiral, including the first. Again, the denominator (*two*) indicates the *number of perpendicular rows of leaves* on the plant which, in the case given being two, each leaf will be distant from its neighbour ½ the circumference of a circle (360°) or 180°. This horizontal distance is called the ANGULAR DIVERGENCE of leaves. Examples of the one-half arrangement of leaves occur in most grasses, and it is technically termed the *Distichous*, or two-ranked arrangement.

FIG. 35.



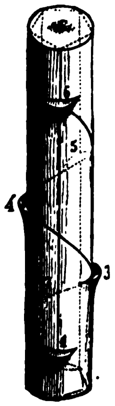
Alternate leaves (Bird Cherry). ½ arrangement.

The type that comes next in complexity is that in which there are three rows of leaves on the plant (*Tristichous*), an arrangement common in Monocotyledons, in which *three* is the typical number. Here, as the spiral, *or cycle as it* is sometimes called, goes round the stem but *once, and passes* three leaves on its way, the fraction is ⅓—

so that the fourth leaf will be immediately above the first, and the angular divergence of each leaf will be $\frac{1}{3}$ of 360°—*i.e.*, 120°—or the third part of a circle.

If now these two fractions ($\frac{1}{2}$ and $\frac{1}{3}$) be taken, their two numerators be added together, and the same done with their denominators, a new fraction $\frac{1+1=2}{2+3=5}$ will be the result. This fraction indicates the arrangement next in complexity to the $\frac{1}{3}$, and from each cycle being made up of five leaves, arranged in five perpendicular rows, it is called the *Quincuncial* or *Pentastichous* arrangement. In this case the string passes twice round the stem, so that the fraction cannot indicate the *angular divergence* measured in terms of a circle, unless the 360° be doubled, but will indicate it in terms of the spiral. This type is the most common in Dicotyledons. By following the law already indicated, of adding together the numerators and the denominators of the two last fractions, the fraction representing the cycle next in complexity may be obtained, so that the arrangement next in complexity to the pentastichous will be indicated by the fraction $\frac{3}{8}$. The whole series of fractions will accordingly be—

FIG. 36.



Phyllotaxy. Diagram of $\frac{2}{5}$ arrangement.

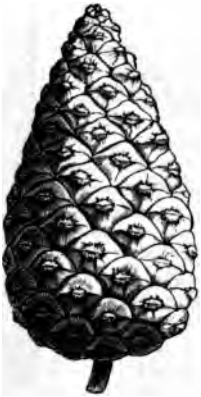
$$\frac{1}{2}\ \frac{1}{3}\ \frac{2}{5}\ \frac{3}{8}\ \frac{5}{13}\ \frac{8}{21}\ \frac{13}{34}\ \frac{21}{55}.$$

The more complex arrangements rarely occur, except in fir-cones (Figs. 37 and 38). In these forms it is sometimes difficult to find out the principal spiral, and to do so, it is usually necessary to trace a number of smaller, or what are called *secondary* spirals. This process is with some difficulty understood by the advanced student, while to the beginner it is useless, and will not therefore be described here.

As a rule, the spirals run in the same direction both on the stem and branches, in which case they are said to be HOMODROMOUS. It occasionally happens, however, that on the stems they run from *right to left*, while on the branches they go from *left to right*. Such leaf spirals are said to be HETERODROMOUS.

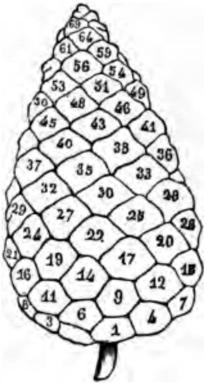
Should the *fraction which* represents the spiral be such *as will not exactly divide the* 360°, which constitute the circumference of the plant, the leaf which should be immediately above the first, will be slightly to the side of a perpendicular line drawn through it, and so on in each successive case. On this account, instead of there being a number of perpendicular rows of leaves, from apex to base, the rows will be curved, hence the term CURVISERIAL which is applied to them. Those which form straight lines are called RECTISERIAL.

FIG. 37.



Complex spirals of a Fir Cone (Pinus Maritimus).

FIG. 38.

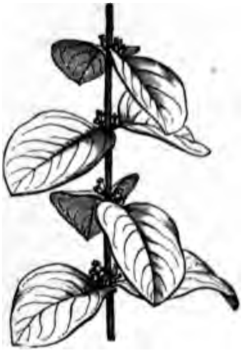


The same, showing the spirals and relative position of the scales.

As leaves originate at the nodes, their vertical distance from each other must depend upon the development of the intervening spaces, or *internodes*. Should these internodes be only developed to a small extent, as is the case in buds, the leaves must overlap each other. Such leaves are said to be IMBRICATED. Examples may be seen in the Stonecrop (Sedum). Where the axis is still shorter, and the leaves are arranged so as to resemble the flower of a rose, they are said to be ROSULATE, as in the Houseleek. Such a disposition is very common in the first year's leaves in such plants as the carrot and turnip. The leaves of these plants are sometimes called radical from their nearness to the roots, in contradistinction to the leaves developed on the stem, called *cauline*, and those produced on the branches (*ramal*). In the branches of some trees, pines, a condition very closely allied to this rosulate arrangement is seen, though the regular disposition is absent. Such leaves are called *fasciculate*, though, by the development of the intervening internodes, they may become *alternate* (ex. Larch).

WHORLED TYPE.—By such a shortening of the axis, the alternate type gradually changes to the other, or whorled type. As has been already seen, there are two modifications *of this*—viz., *the opposite* (Fig. 39) *and whorled* (Fig. 40), according to the number of leaves on the same level. Even here, however, the universal law of alternation prevails, for the one whorl alternates with that next it, so that were the whorls brought to the same level, the leaves of the one would fit into the spaces between the leaves of the other immediately above or below it. This is called *Decussation*. It will probably be better understood if the case of opposite leaves be taken, with one pair pointing north and south: if the pairs immediately above and below these be examined, they will be found to point east and west, while the third above *and the third* below will be directed north *and south again.*

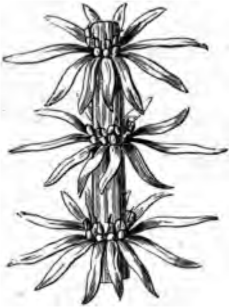
FIG. 39.



Opposite leaves.

When two leaves appear to rise at the same level, the phenomenon is due to the non-development of the internode which should separate the one from the other; that is to say, one internode has remained undeveloped or is suppressed. Where three leaves originate on a level with each other, two internodes have remained undeveloped, and so on; the number of undeveloped internodes being always one less than the number of leaves in the whorl.

FIG. 40.



Verticillate or whorled leaves (Hippuris vulgaris).

That such is really the case, may be shown by the existence of all kinds of arrangements on one stem, as occurs in the Rhododendron Pontica, and by the tendency of some whorled leaved plants to become alternate by cultivation. As a rule, however, it may be stated that the arrangement of the leaves is constant in the same plant, or even family of plants. Thus, alternate leaves prevail in the Boraginaceæ; in the Labiatæ they are opposite; while in the Rubiacæ they are whorled. The disposition of the leaves is in some cases accompanied by corresponding peculiarities of the stem: thus the Boraginaceæ with alternate leaves have rounded stems, while the Labiatæ with opposite leaves have square stems.

PARTS OF THE LEAF.

Having now considered the leaf in its *general* relations, *it remains to* consider it *specially*.

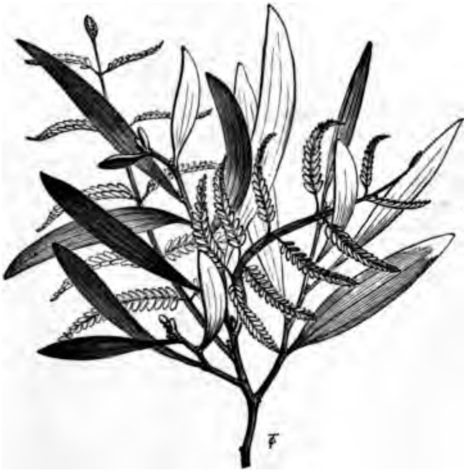
The spot where a leaf is joined to the stem is called its INSERTION, and the connexion is effected either by a *joint or articulation*, or the leaf appears to be *directly inserted* into the stem. When the leaf is jointed, it breaks off at the joint when it falls; while in the cases where the joint is absent, the leaf gradually withers down, leaving a ragged scar behind it. The mark left by the falling of the leaf is called the CICATRIX, or scar, and a swelling immediately below it is called the PULVINUS.

A perfect leaf consists of the following parts:- 1st, the VAGINA, or SHEATH, that portion of the leaf which, at its insertion, surrounds the stem wholly or partially; 2nd, the continuation of this sheath known as the PETIOLE, or FOOTSTALK; and 3rd, the flattened portion called the LAMINA, or BLADE. To these, in some cases, are added what are called STIPULES. Of all parts of the leaf, the blade, which makes its appearance first, is that most frequently present. Should the development of a leaf be arrested after the blade has been formed, but before the footstalk has made its appearance, the leaf will be SESSILE. When, on the other hand, a petiole is present, the leaf is said to be PETIOLATE. It occasionally happens, from the destruction of the blade, or its partial development, that some other part must supply its place; this, in some instances, is done by flattening of the petiole, in others by an increased development of the stipules.

PETIOLE AND VAGINA.—The petiole is usually rounded below, and flattened or hollow above, so that its transverse section is either semicircular or crescentic. In the Aspen the petioles are flattened laterally, which produces the fluttering of its leaves in the slightest breath of wind. Petioles are either *simple* or *compound*, according as they support one or more laminæ. The sheathing portion of the footstalk or VAGINA, is best seen in Monocotyledons. In the grasses it completely surrounds the stem, but its adjacent sides are not united, as they are in the sedges (Carices).

PHYLLODES.—When the blade of the leaf proves abortive or falls off, the petiole may be so modified as to take its place, in which condition it is called a PHYLLODE. Such leaf-like organs may be distinguished from true leaves by having their flat surfaces lateral, and not horizontal, so that their edges are *vertical. Their venation is also straight even in Dicotyledons. In the Acacia* heterophylla (Fig. 41), every intermediate form between perfect compound leaves and perfect *Phyllodes* may be seen.

FIG. 41.



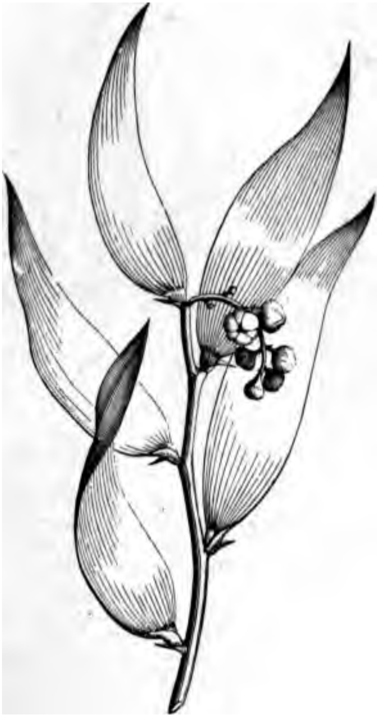
Phyllodes and compound leaves (Acacia heterophylla).

Again it may happen that branches may become flattened and leaf-like (Fig. 42), and fulfil all the functions of leaves. In some instances the whole stem seems to be endowed with the same properties as leaves, the leaves remaining in an undeveloped or imperfect state (Fig. 43).

LAMINA, OR BLADE.—At its distal extremity the petiole usually ends in a broad plate flattened from above downwards, which is called the LAMINA, OR BLADE of the leaf. This presents a greater number of modifications than any other part of the leaf; and as it is chiefly by these variations that botanical species are distinguished, it is necessary to obtain some acquaintance with them, although from the multitude of terms employed to distinguish very slight differences, the subject is far from inviting.

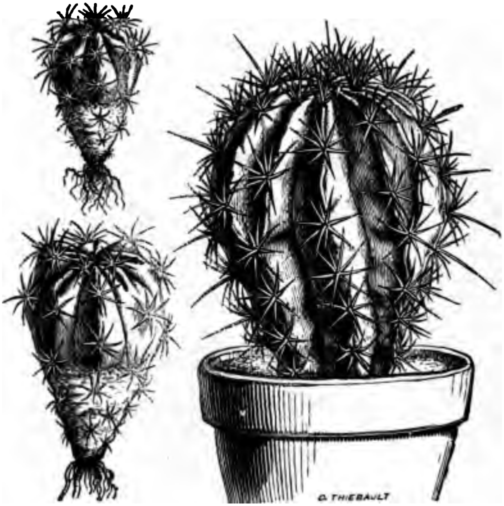
Ordinary blades possess two *surfaces*, an upper and a *lower, or superior* and inferior. The point of the leaf which is farthest from the stem, and which is the oldest part of the leaf, is called the *apex;* the part next the stem is called the *base*, and the edges joining these two the *margins*. Occasionally the blade, instead of being flat, is *cylindrical*, as in *the onion (Fig. 44)* and rush, or prismatic, *as in Mesembryanthemum.*

FIG. 42.



Flattened and leaf-like branches rising in the axils of scaly leaves (Danaida).

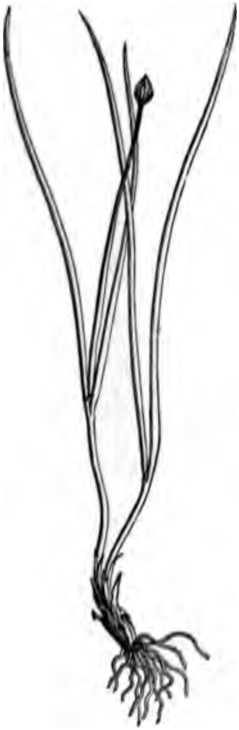
FIG. 43.



Green and fleshy stems of Echinocactus spiralis at various stages.

SIMPLE AND COMPOUND LEAVES.—There are two grand types of leaves, the *simple* (Fig. 45) and the *compound* (Fig. 46). The distinction between the two is founded on the number of laminæ, or the number of joints each leaf possesses. There is usually a joint where the leaf is attached to the stem; should any more joints occur, the leaf will be a COMPOUND one, whereas, if there be one only, or none at all, the leaf is said to be SIMPLE. Another definition of a compound leaf is, that it is one whose petiole bears *more than one distinct blade.* But a case may be easily imagined where all the lateral leaflets have fallen off, leaving the terminal leaflet only. Such a leaf, though it had but one leaflet, would certainly be compound. A state somewhat analogous to this is seen in the orange tree, where the petiole is terminated by a single *leaflet* (as the individual blades are called in compound leaves), but the lamina *being jointed to* the petiole, the leaf is held to be a *compound one.* The simple leaf passes gradually into the

FIG. 44.

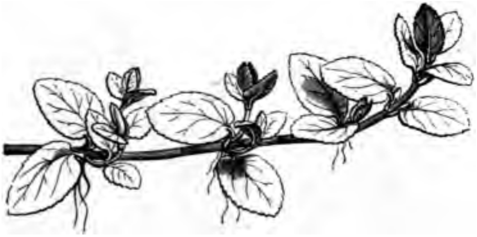


Rounded leaves of a species of Onion.

compound one by certain modifications, to be mentioned hereafter.

VENATION.—The subdivisions of the petiole, when it enters the blade, constitute the *skeleton* of the leaf. The larger branches are called RIBS, the smaller VEINS or NERVES. The plan *on which these* branches are arranged is *termed the* VENATION *of* the leaf.

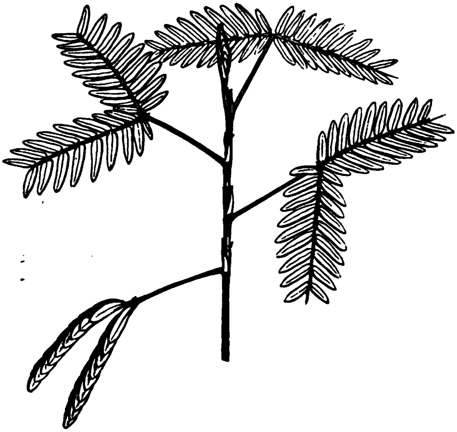
FIG. 45.



Simple leaves of various sizes, Veronica.

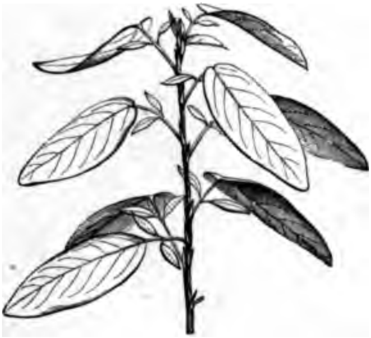
When the petiole appears to be continued into the bl that part of it in the blade is called the MIDRIB. So times the midrib gives off subdivisions from its sides the veins of a feather (Fig. 49). Leaves having such arrangement of veins are termed PENNINERVED.

FIG. 46.



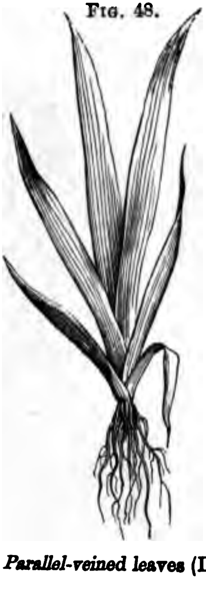
Compound leaves—paripinnate (Sensitive plant).

FIG. 47.



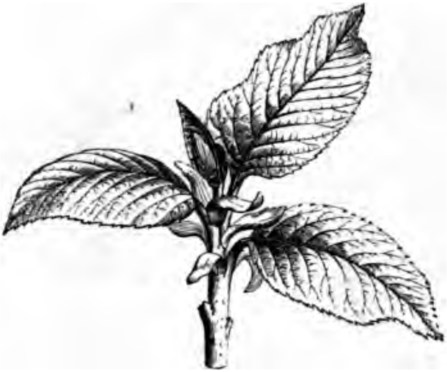
Compound leaves, with large terminal leaflet and two small lateral leaflets.

FIG. 48.



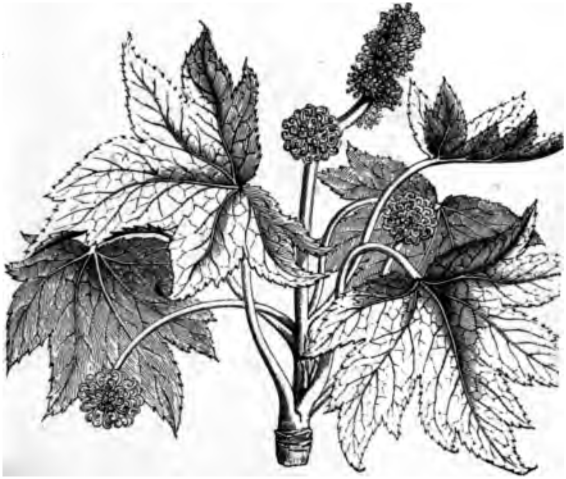
Parallel-veined leaves (Iris).

FIG. 49.



Feather-veined (Penninerved) leaf of Elm.

FIG. 50.

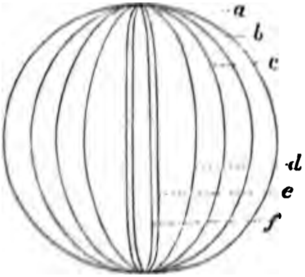


Palmi-nerved leaves of Liquidambar styraciflua.

Again, when the petiole enters the blade, it may be cut up into several divisions, none of which can be said to be its continuation, and these primary divisions of the petiole may pass straight on from the base to the apex of the blade, producing *straight* or *parallel*-veined leaves (Fig. 48). When these veins are slightly curved they give rise to *curvinerved* leaves. When the veins radiate in all directions from the junction of blade with the petiole as from a common centre, such leaves are termed *palminerved* leaves (Fig. 50).

The shape or outline of leaves is of great consequence in the determination of species. These various shapes will be best understood by reference to the accompanying diagrams.

FIG. 51.

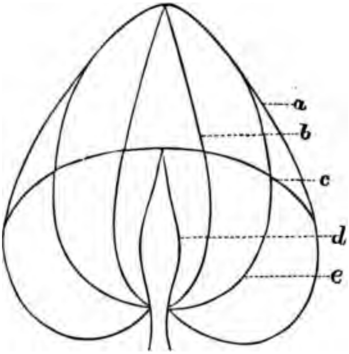


a, Orbicular; *b*, Subrotund; *c*, Oval or Elliptical; *d*, Oblong; *e*, Linear; *f*, Acicular.

The mode in which the secondary divisions of the veins are arranged comes to be of great importance in systematic Botany. In Monocotyledons, the smaller veins cross each other at right angles, and the larger are straight and parallel; hence their venation is said to be STRAIGHT or PARALLEL. In Dicotyledons, the smaller divisions cross each other at any angle, and the larger divisions have not a very straight course, so that they form a rather irregular network pattern, best seen on the lower surfaces of the leaves. On this account the leaves of Dicotyledons are said to have a RETICULATE or NETTED venation. A small group of Monocotyledons have a somewhat similar kind of venation, and are termed DICTYOGENS.

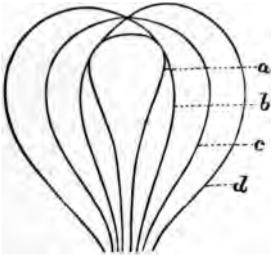
In most cases, the midrib divides the leaf into two and symmetrical parts, but occasionally one side is than the other, when the leaf is said to be *oblique.*

FIG. 52.



a, Cordate; *b*, Lanceolate; *c*, Reniform; *d*, Subulate; *e*, (

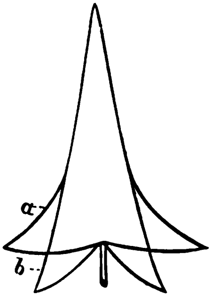
FIG. 53.



a, Spathulate; *b*, Oblanceolate; *c*, Obovate; *d*, Obcorda

It sometimes happens, in sessile leaves, that the portions of the blade are prolonged backwards like of ears, when the leaf is said to be *auriculate* whe *but amplexicaul,* when the ears adhere to the ste *besides adhering* to the stem each ear grows to it fo distance downwards, the leaf is said to be *decurrent*, and the stem is said to be *winged* (*alate*). Should, again, the two ears pass far enough backwards to unite on the other side of the stem, the leaf is said to be *perfoliate;* while if two leaves should happen to be opposite, and their bases become united, they are said to be *connate*. In petiolate leaves again, should the ears be so far prolonged backwards as to unite, they will give rise to the form of leaf termed *peltate*, where the stalk appears to be attached to the centre of the blade like the handle to an umbrella. In these cases the leaves are usually *orbicular* or *circular*, and are much the same as *perfoliate*, if in this last case the stem be supposed to terminate in, and not pass through the leaf.

FIG. 54.

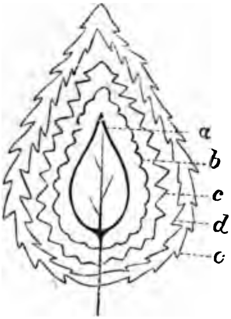


a, **Hastate**; *b*, **Sagittate.**

APEX.—The APEX of the leaf may either be prolonged into a sharp point, when it is said to be *acute*, or if prolonged to a greater extent, *acuminate*. When the point is still sharper and harder, it is said to be *cuspidate*. Finally, when a short, sharp point springs from a blunt-ended leaf, it is described as *mucronate*. On the contrary, the leaf may end in a blunt point, when it is said to be *obtuse;* or there may be a slight hollow, when the apex is said to be *emarginate*, and when this hollow is large and shallow, it becomes *retuse*.

MARGIN.—With regard to the MARGIN, it may be entire (Fig. 56) when there is no indentation whatever; it is termed *crenate* (Fig. 57) when there are slight rounded projectio When the projections are sharp, and at right angles to leaf it is described as *dentate* (Fig. 58); *serrate* when

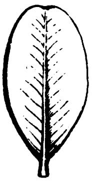
FIG. 55.



a, Entire leaf; *b*, Crenate leaf; *c*, Dentate leaf; *d*, Serrate leaf; *e*, Retroserrate leaf.

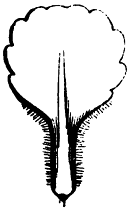
sharp points are directed to the apex of the leaf; when th points are turned towards the base the margin is descri as *retro-serrate*. When the rounded projections of crenate form become very large, the leaf is said to be REPA

FIG. 56.



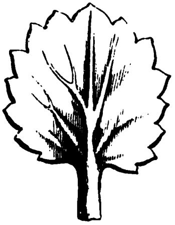
Entire leaf emarginate.

FIG. 57.



Crenate leaf.

FIG. 58.

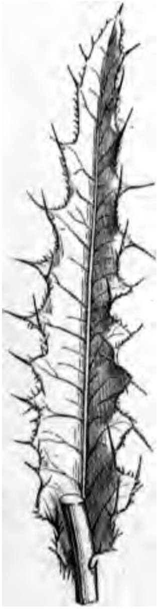


Dentate leaf.

Frequently the indentations are deeper than any *those yet mentioned*, dividing the leaf into two or n *distinct lobes*, when the leaf is called bilobed, trilobed, according to the number of its segments. When these divisions get too numerous to be so distinguished, another nomenclature is adopted, founded upon the nervation of the leaf.

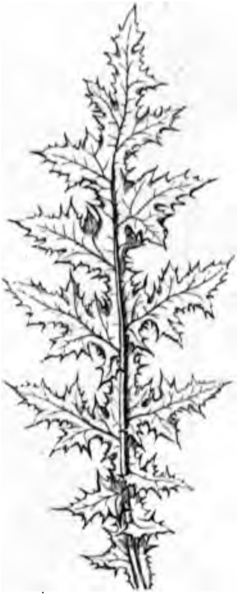
In a feather-veined (*Penninerved*) leaf (Fig. 48) the incisions will correspond with the spaces between the veins, and must therefore have a similar arrangement. If they be not therefore very deep, the leaf will be called PINNATIFID (Fig. 59); if they penetrate to a greater extent, PINNATISECT (Fig. 60); and if they almost reach the midrib, the leaf will become PINNATIPARTITE (Fig. 61). A similar *division holds good* with Palmate leaves; viz., *into* PALMIFID *(Fig. 62)*, PALMISECT (Fig. 63), and PALMI-

FIG. 59.



Pinnatifid leaf.

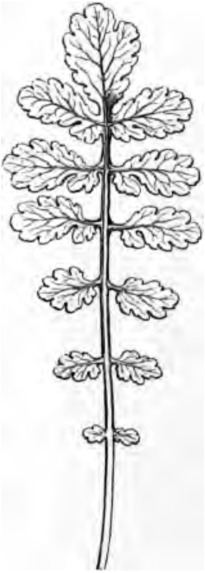
FIG. 60.



Pinnatisect leaf.

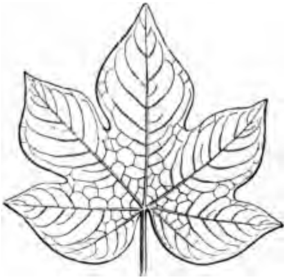
PARTITE (Fig. 64). A modification of the Palmate type, where there is a greater number of ribs than usual, the lower of which turn backwards towards the petiole, is called a PEDATE (Fig. 63) leaf, and of this there are the same divisions. Should the subdivisions be cut up like the original leaf, the term *bi* is prefixed, as *bifid, bisected*, &c., and if this process be repeated, the term *tri* is used, as in *trifid*, *&c.; when cut up* to a greater extent, the leaf is said to *be* DISSECTED, as is seen in *submerged* leaves (Fig. 65).

FIG. 61.



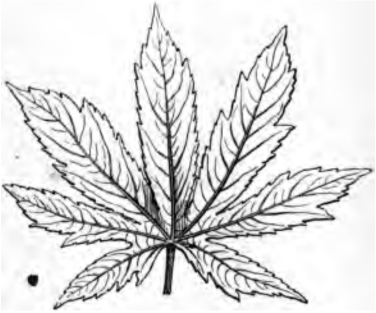
Pinnatipartite leaf (Chelidonium).

FIG. 62.



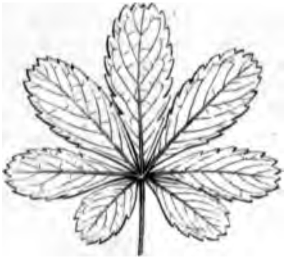
Palmifid leaf.

FIG. 63.



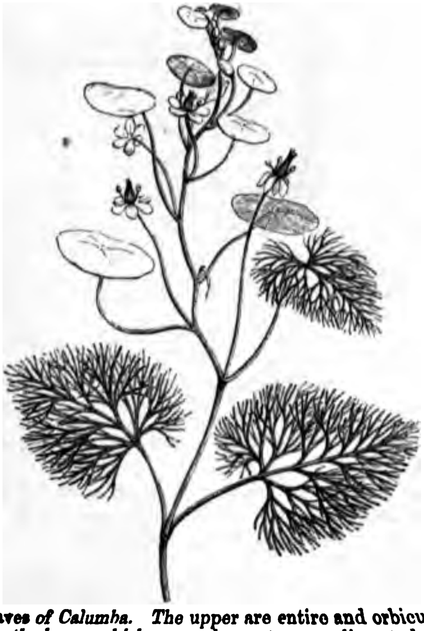
Palmisect and Pedate leaf.

FIG. 64.



Palmipartite leaf (Potentilla).

FIG. 65.

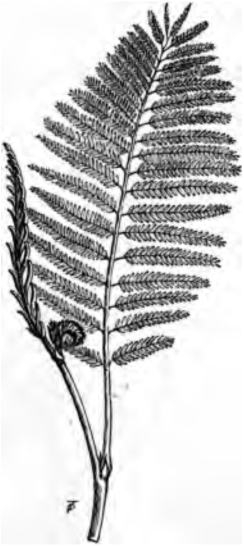


Leaves *of Calumba. The* **upper are entire and orbicular ;** *the lower, which* **are under water, are dissected.**

COMPOUND LEAVES.—It has been seen that if the incisions in the blade nearly reach the midrib, the leaf is said to be PARTED (PARTITE); should they reach the midrib, a compound leaf, according to one of the definitions already given, will be produced. This will, therefore, be a convenient place for the description of COMPOUND LEAVES.

With regard to the individual parts of a compound leaf (LEAFLETS or FOLIOLI), whether sessile on the *common* *petiole* or *rachis*, or supported upon *secondary petioles* (*petiolules*), exactly the same terms are used for their description, as to shape, apex, margins, &c., as in the case of simple leaves.

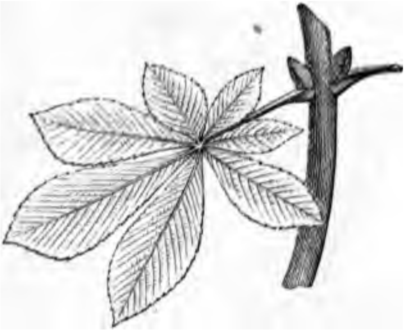
FIG. 66.



Decompound leaf of Acacia grandiflora. Pinnate type.

Compound leaves are divided into two groups according *to the two great* types of venation, the *Pinnate* and the *Palmate.* *It* usually happens among the pinnate forms that the leaflets are arranged in pairs, and these pairs are called JUGA, so that a compound leaf with one pair of leaflets would be called a *unijugate* leaf. When there is no leaflet terminating the rachis, so that the number of leaflets on its sides is even, the leaf is said to be *paripinnate* (Fig. 46); if a terminal leaflet be present, *imparipinnate.* When the pairs are alternately large and small, the leaf is said to be *interruptedly pinnate*, and when the rachis gives off not single leaves but branches, which in their turn give off other branches, supporting leaves, the leaf is said to be DECOMPOUND (Fig. 66).

FIG. 67.



Compound leaf of Horse Chestnut. Palmate type.

The leaflets in the other type of compound leaf, called the PALMATE or DIGITATE form, produce *ternate*, *quinate*, &c., forms according to their numbers.

As to their consistence, leaves are *membranous*, *fleshy*, *leathery*, &c , terms which require no explanation.

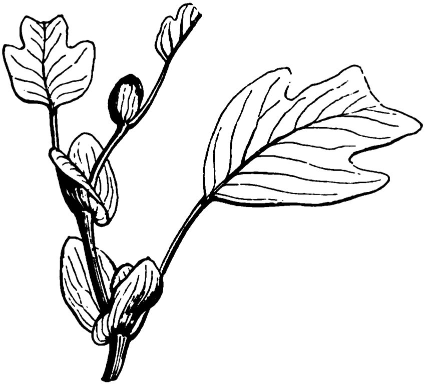
As to duration, they are DECIDUOUS if they fall in autumn, or PERSISTENT if they last over winter, as they do in evergreens.

As to surface, leaves may be *smooth* (*glabrous*), *hairy* (*pilose* or *hirsute*), or furnished with stiff hairs (*hispid*), *rough* (*scabrous*), *bristly* (*setose*), *viscous*, when they have glandular hairs, *scaly*, *scurfy*, &c.

STIPULES.

On either side of that point where the leaf joins the stem, small membranous expansions are often seen, the presence or absence of which affords valuable characters for distinguishing plants. These organs are called STIPULES, and leaves possessing them are said to be STIPULATE, and when they are wanting, EXSTIPULATE. As to the nature of these organs, various opinions are entertained, some looking upon them as *partially developed leaves*, others, with greater probability, holding that they are *portions of the leaf sheath* (vagina), developed in a peculiar manner. They vary greatly in size and duration. Sometimes they are absent as in Monocotyledons, or, again, they may be very large, performing the function of the true leaf, as in Lathyrus Aphaca (Fig. 79). Occasionally they fall off when the bud opens, as in the Beech, while in other cases they remain as long as the leaf exists.

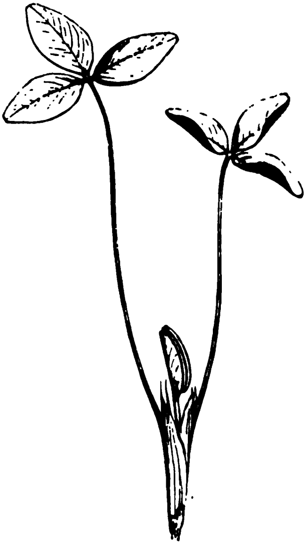
FIG. 68.



Free lateral stipules (Tulip tree).

The normal condition of stipules is that of two free lateral expansions (Fig. 68) at the base of the leaf, as is *seen in the* Willow, in which condition they are called **FREE** *or* **CAULINARY** *stipules*. In some plants, as the Rose, they

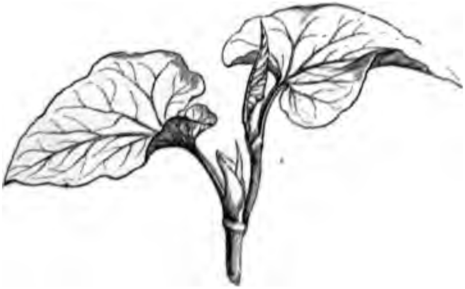
FIG. 69.



Adnate or petiolar stipules (Trifolium pratense).

adhere to the petiole, when they are said to be ADNATE (Fig. 69).

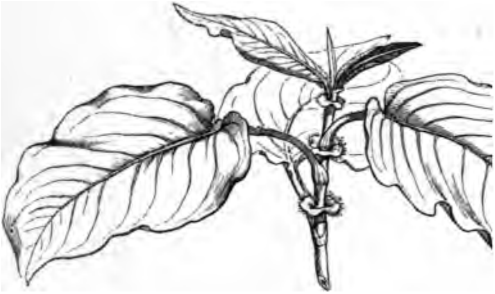
FIG. 70.



Axillary stipules.

When stipules unite the one with the other said to be CONNATE (Fig. 72), of which there are thı fications. Sometimes the two stipules unite, form a single organ in the axil of the leaf, and

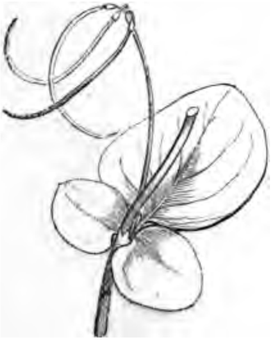
FIG. 71.



Axillary stipules forming an ochrea (Polygonum Orier

between the leaf and the stem, when they are s AXILLARY (Fig. 70) or INTRAFOLIACEOUS. Should joined stipules be large enough to surround t stem, the sheath is called an OCHREA, examples

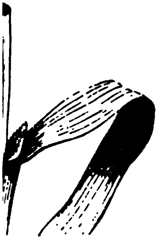
FIG. 72.



***Ornithopus* scorpioides, showing a small scaly bilobed orga *the leaf.* This is composed of the two connate stip**

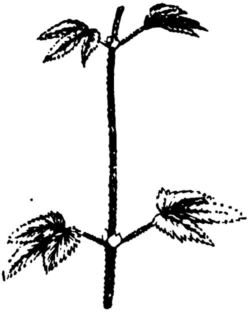
to be seen in the Rhubarb and other Polygonaceæ
. 71).
gain, instead of uniting between the leaf and the stem,
may unite on the opposite side of the stem (INTRA-
OLAR STIPULES) (Fig. 72), and thus, if large enough to
nble a leaf, may simulate the opposite arrangement
aves, where they are really alternate. When there
wo leaves on the same level, their stipules may unite
e of the one with the stipules of the other, and thus
simulate whorled leaves. Such stipules are said to
TERPETIOLAR (Fig. 74). In Grasses, a small mem-

FIG. 73.



gula (Milium multiflorum).

FIG. 74.



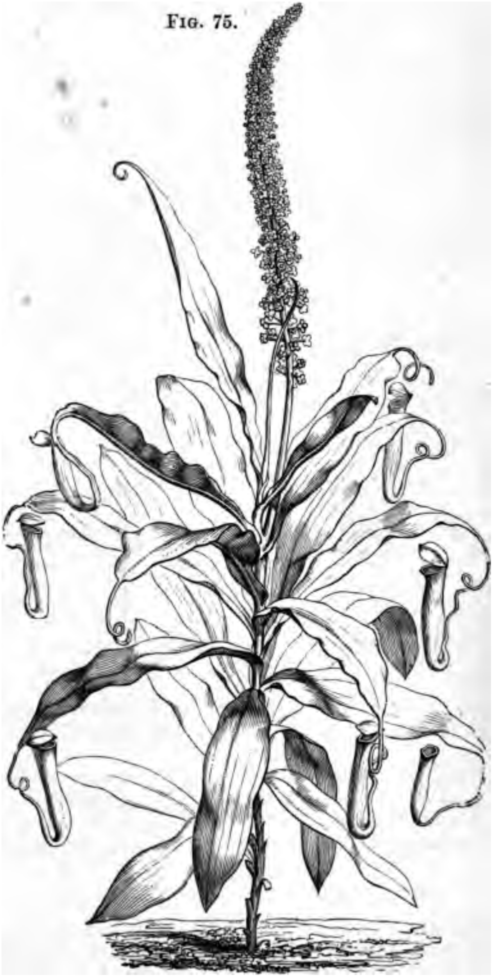
Interpetiolar stipules of the Hop.

ous organ called a LIGULE (Fig. 73), occurs in the axil
ch leaf, and is supposed to be constituted by axillary
les.
hen in compound leaves small stipules occur at the
of the secondary leaflets, they are called STIPELS.
metamorphoses of stipules will be described with
e of leaves, to which attention will next be directed.

Metamorphoses of the Leaf and its Parts.

has already been mentioned, that in some cases the
na or blade of the leaf falls off, or is never developed
n some other organ assumes its functions, such an
n being *called a PHYLLODE.*

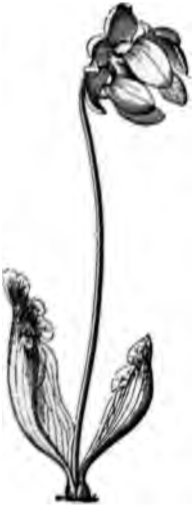
FIG. 75.



Nepenthes distillatoria. The true Pitcher plant, showing each l
to consist of phyllodes, tendrils, pitchers, and lids.

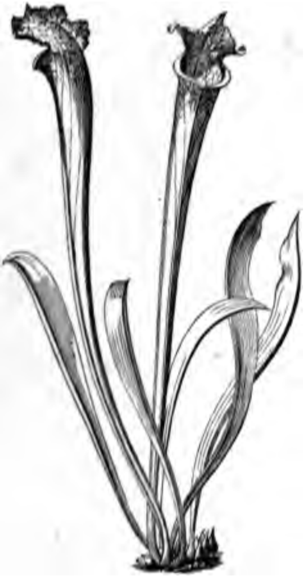
PITCHERS.—One of the strangest metamorphoses which leaves undergo is into Pitchers, of which there are various sorts. Thus in the Nepenthes, or true pitcher plant (Fig. 75), the part of the petiole next the stem is flattened and leaf-like, beyond which it contracts and forms a sort of tendril, but again expands so as to form the pitcher, which is surmounted by a small lid, joined to the pitcher by a hinge —this lid is the true blade of the leaf. In the Sarracenia again, the pitcher is formed from the blade, not from the petiole, for there is no joint between the lid and the pitcher (Figs. 76 and 77). Several other plants have pitchers more or less allied to these in shape and structure. In some cases *the petiole* is inflated so as to serve as a *float to the plant (ex. Trapa).*

FIG. 76.



Pitchers (Sarracenia).

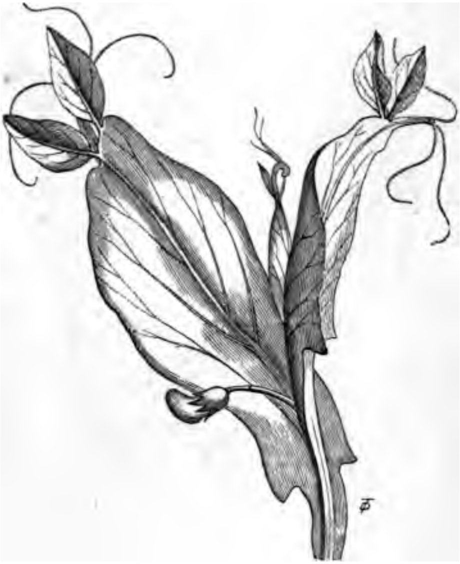
FIG 77.



Pitchers (Sarracenia).

TENDRILS.—There is no modification of the leaf m common than the *tendril*, a thread-like process, by wh climbing plants attach themselves to surrounding obje In the *Lathyrus*, where the leaf is compound, some of leaflets are often converted into tendrils (Fig. 78), while stipules or other parts perform the functions of the leaves.

FIG. 78.



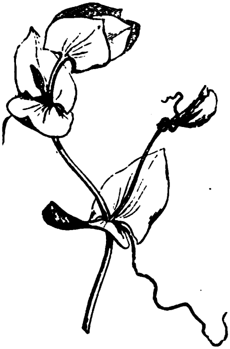
Lathyrus platiphyllos leaflets partly converted into tendrils. Leaves replaced by flattened petioles.

Lathyrus Aphaca (Fig. 79) all the leaflets are thus verted into tendrils, while in the common Pea sev undergo a similar metamorphosis.

The tendrils of the Gloriosa superba are prolongat of the midrib.

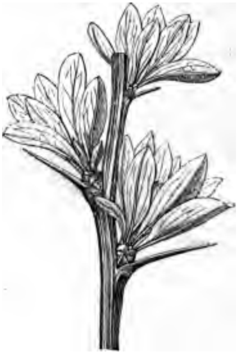
In the Cucurbitaceæ, the solitary tendril is probab *modified* condition of two coherent axillary stip he stipules of the Sarsaparilla plant are trans- into a pair of tendrils. In the Vine, as already out, the tendrils are metamorphosed flowering es.

FIG. 79.



ves converted into tendrils eplaced by stipules (Lathy- phaca).

FIG. 80.



Thorns of the Barberry.

RNS.—Many plants are armed with thorns formed some portion of the leaf modified. Thus in the the extremities of the veins are hardened, and of the thorns of the Furze (Ulex) are really hardened . The thorns of the Barberry (Berberis) may bly be referred to the same part. In the Astra- again, the blade falls early, and the petiole becomes and thorny, while in the Robinia pseudacacia, the are transformed stipules. In the Gooseberry the teral thorns are also modified stipules, the third either a projection from the pulvinus, or a modified

OFFICINAL LEAVES.

m—fresh leaves and flowering s of Aconitum *Napellus,* act. n. *Aconitia*	Sedative, &c.
leaves of Barosma Betulina, B. *ulata and B. serratifolia*	Diuretic, &c.

Senna { Alexandrina—leaf of Cassia lanceolata and C. obovata...... Indica—leaf of Cassia elongata }	Smart Purgative.
Lauro-cerasus—leaves of Prunus Lauro-cerasus (yield Prussic Acid)	Sedative.
Conium—fresh leaves and branches of Conium maculatum, act. prin. Conia	Sedative.
Uva Ursi—leaf of Arctostaphylos Uva Ursi	Astringent and Diuretic.
Belladonna—recent and dried leaf of Atropa Belladonna, act. prin. Atropia	Sedative and Anodyne.
Folia Stramonii—dried leaves of Datura Stramonium, act. prin. Daturia ...	Antispasmodic.
Hyoscyamus—fresh and dried leaves and young branches of Hyoscyamus niger, act. prin. Hyoscyamia	Sedative and Anodyne.
Tabacum—dried leaf of Nicotiana Tabacum, act. prin. Nicotina...............	Sedative.
Digitalis—dried leaf of Digitalis purpurea, (act. prin. Digitalinum officinale)	Sedative, Diuretic, &c.
Matico—leaf of Artanthe elongata	Astringent & Hæmostatic
Melaleuca minor—leaves yield Cajeput Oil.	
Aloe vulgaris—leaves yield Aloes.	
Uncaria Gambir—leaves yield pale Catechu.	

NON-OFFICINAL, USED IN MEDICINE.

Ruta—leaf of Ruta graveolens	Stimulant & Antispasmodic.
U.S. (Rhus Toxicodendron—leaves of Rhus Toxicodendron	Local Irritant, used in palsy).

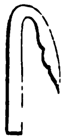
CHAPTER IV.

MORPHOLOGY.

BUDS—VERNATION.

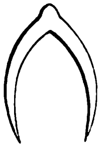
Buds are divided into *leaf-buds* and *flower-buds*. The former are devoted to the production of the *vegetative*, the latter of the *reproductive* organs. Both kinds are composed of rudimentary leaves, but there are certain modes of arranging these found in the one case, and not in the other.

Fig. 81.



Reclinate Vernation.

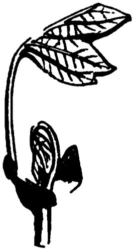
Fig. 83.



Conduplicate Vernation.

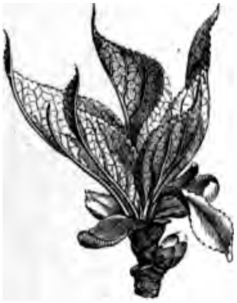
When a bud has to last over winter (a *resting* bud), it

Fig. 82.



Bud of Tulip-tree.
Reclinate Vernation.

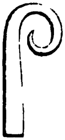
Fig. 84.



Bud of the Almond.
Conduplicate Vernation.

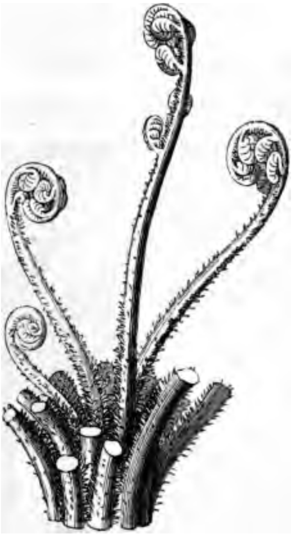
is usually protected by scales, termed *bud-scales*, or TEGMENTA. These may be modifications of the blade of the leaf—*i.e., foliaceous*, as in the Pine family; or they may be *petiolar*, as in the Horse-chestnut, or *stipular*, as in the Oak. Besides scales, buds have sometimes other

FIG. 85.



Circinate Vernation.

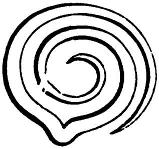
FIG. 86.



Circinate Vernation, as seen in Ferns.

protecting organs, as hairs in the Willow. The buds of the Poplar secrete a resinous substance when about to enlarge. Buds which want such scales or other coverings are said to be NAKED.

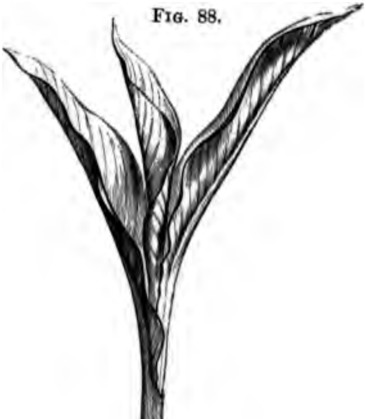
FIG. 87.



Convolute Vernation.

The arrangement of leaves in a leaf-bud is called VERNATION or PREFOLIATION ; in a flower-bud, ÆSTIVATION or PREFLORATION. By these terms, however, two distinct

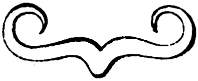
FIG. 88.



Bud, showing Convolute Vernation.

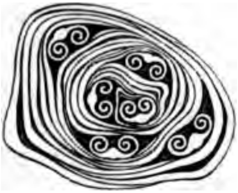
things are implied—viz., 1st, *the arrangement* of the leaves *with regard to themselves*—that is to say, the mode in which they are folded; and 2nd, *the arrangement leaves with regard to each other.*

Fig. 89.



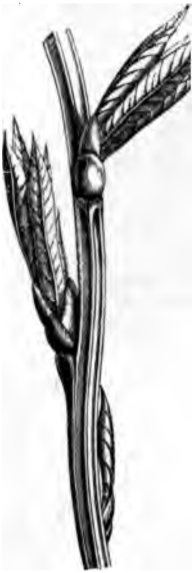
Involute Vernation.

Fig. 91.



Cross section of an involute bud.

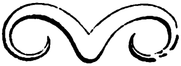
Fig. 90.



Buds showing Involute Verr

Leaf Folding.—In considering the arrangen leaves with regard to themselves, it will be foun there are two typical modes of leaf folding, of wh *others are* simple modifications. The one mi

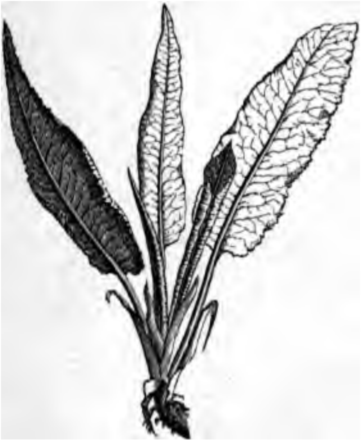
Fig. 92.



Revolute Vernation.

termed the VERTICAL, the other the HORIZONTAL type. In the vertical type when the leaf is so folded that the apex

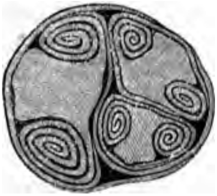
FIG. 93.



Revolute Vernation.

is applied to the base, the mode of leaf folding is called RECLINATE (Fig. 81), as in the Tulip-tree (Fig. 82). When the two edges of the leaf are brought in contact, the leaf

FIG. 94.

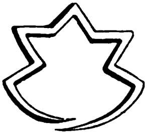


Section of a Revolute Bud.

being folded with the midrib as a centre, as in the Oak, the *mode of folding is termed* CONDUPLICATE (Figs. 83 and 84

When instead of being simply folded, the leaf is rolled up according to the vertical type, that is, beginning with the apex and rolling up to the base, the vernation is said to be CIRCINATE (Fig. 85) as in Ferns (Fig. 86). If the rolling is according to the lateral type, that is, beginning at one side and going on to the other, it is called CONVOLUTE (Fig. 87), as is seen in the Cherry (Fig. 88).

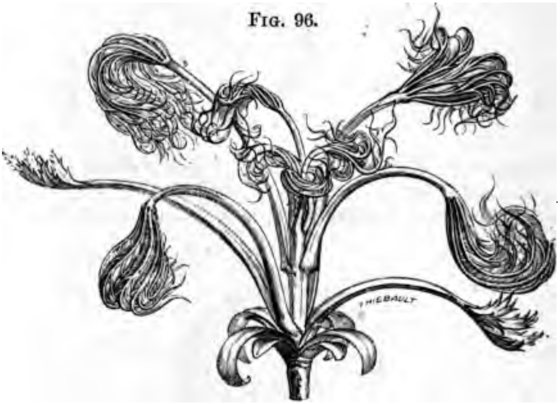
FIG. 95.



Plicate Vernation.

Sometimes, instead of being rolled from side to side, the rolling may be commenced at both sides simultaneously, proceeding towards the midrib. If the leaf be then rolled forwards, that is, towards its face, the arrangement is called INVOLUTE (Fig. 89), and is seen in the *buds of the* Water Lily and Poplar. If the rolling be *directed to*wards the back of the leaf, as may be seen in

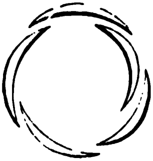
FIG. 96.



Young leaves showing Plicate Vernation.

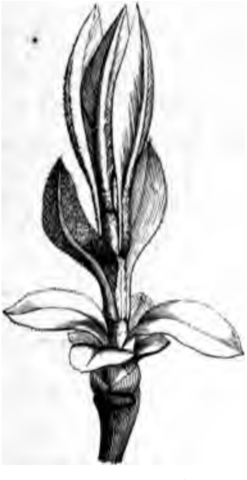
Lavender, &c., it is said to be **Revolute** (Fig. 92). A modification of the conduplicate, also belonging to the folded group, is called **Plicate** (Fig. 95). Here, besides the single fold, there is a sort of plaiting of the lateral halves of the leaf; examples of it occur in the Vine, Currant, &c. (Fig. 96).

Fig. 97.



Imbricate Vernation.

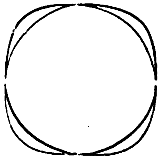
Fig. 98.



Imbricate Vernation.

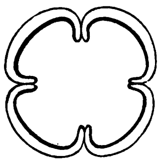
Leaf Grouping.—*As to the plan on which leaves are arranged with regard to each other, it will be found the* this will vary according to the phyllotaxy of the species. If the leaves be arranged quincuncially (according to the $\frac{2}{5}$ arrangement) the vernation will probably be IMBRICATE (Fig. 97), in which case the leaves overlap each other in a peculiar manner, three being partly within, partly without, one entirely within, and one entirely without the others. If, again, the leaves be whorled, the VALVATE arrangement (Fig. 99) will most probably be encountered: in this case the leaves merely touch each other by their edges, and do not overlap at all; if, however, this be excessive, then the adjacent edges of the touching leaves may be directed inwards, and the arrangement known as the INDUPLICATE (Fig. 100) will result.

FIG. 99.



Valvate Vernation.

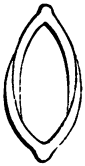
FIG. 100.



Induplicate Vernation.

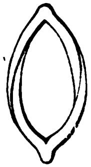
When leaves are opposite, or alternate, but arranged in two rows (distichous) one of two kinds of vernation will usually be found. Either, the leaves being conduplicate, the one will embrace both edges of its opposite neighbour, when the vernation is called EQUITANT (Fig. 101), or only *one edge,* when it is called HALF EQUITANT (Fig. 102). The *term OBVOLUTE* is also applied to the last variety, but,

FIG. 101.



Equitant Vernation.

FIG. 102.

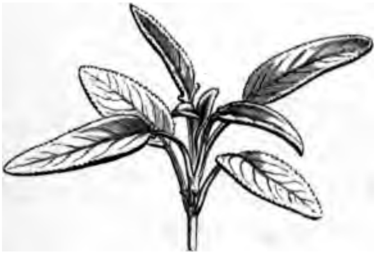


Half-equitant Vernation.

implying as it does the idea of rolling, should not be used, being likely to confuse the student.

The student, by a piece of paper cut in the shape of a leaf, may easily make himself acquainted with these modifications of leaf-folding, in a far more satisfactory manner than by mere diagrams.

Fig. 103.



Half-equitant Vernation.

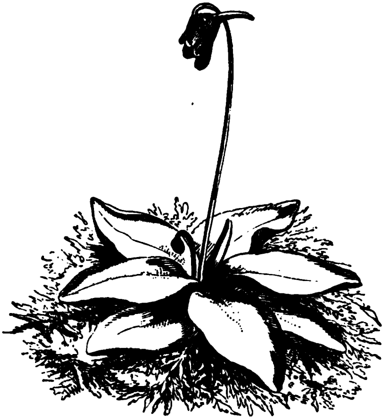
CHAPTER V.

MORPHOLOGY.

INFLORESCENCE.

BUDS are of two kinds—the one set devoted to t repetition of the individual, and termed *Leaf-buds*, t other intended to reproduce the species, and call *Flower-buds*. The flower-bud either terminates the a (*terminal bud*) or originates in the axil of a leaf (*axilla bud*). This leaf is frequently modified as to shape a colour and is called a BRACT. By the development of t flower-bud it gives rise to one or more flowers, variou arranged on the flowering axis. These flowers constit the INFLORESCENCE of the plant, which, according the position of the flower-bud, is either TERMINAL AXILLARY.

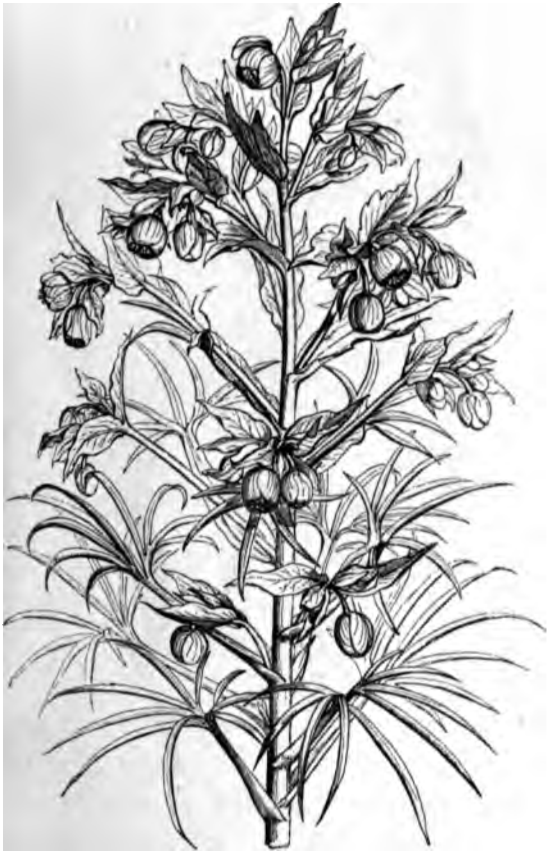
FIG. 104.



Scape of Pinguicula.

In most cases the flower is supported on an axis, cal *the* FLOWER-STALK or PEDUNCLE, but when this gives secondary branches it is called a RACHIS, and the branches are denominated PEDICELS, while the leaves at the bases of these are called BRACTEOLES or BRACTLETS.

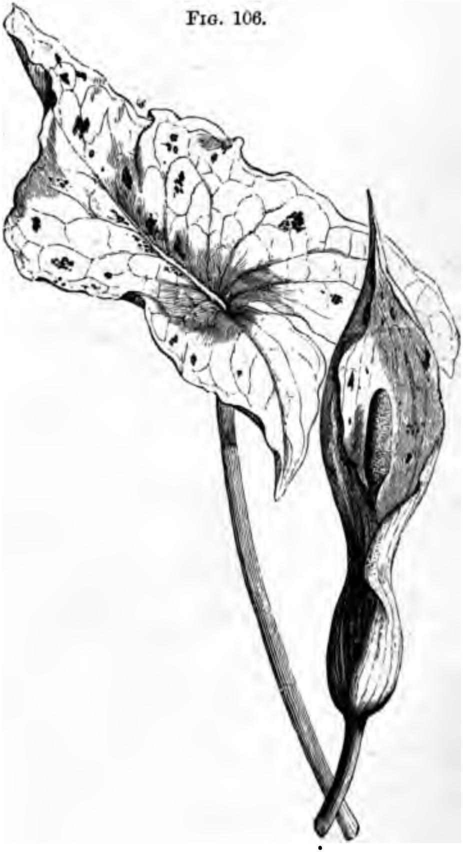
FIG. 105.



Helleborus fœtidus, showing the transition of leaves into bracts.

Many plants which have their stems underground, s up naked stalks crowned with one flower, as in

Fig. 106.



Leaf, spadix, and spathe of Arum maculatum.

Primrose, or with more than one, as in the Cowsli *Such stalks* are called Scapes (Fig. 104).

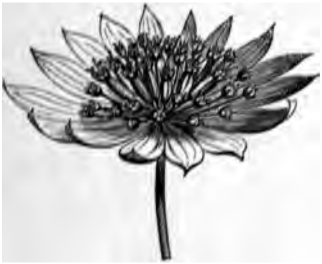
BRACTS.

Sometimes bracts cannot be distinguished from true leaves, except by having flower-buds in their axils. This may be seen in the Foxglove (Digitalis). In other cases they are modified, as to shape, as in the Hellebore (Fig. 105), or, as to colour, as in the Sage. In the Mustard family (Cruciferæ) they are often wanting.

Occasionally bracts are so modified as to be taken for the flower itself. This is seen in the Trumpet Lily (Richardia), where a large coloured bract, called a SPATHE, encloses the inflorescence. The same arrangement occurs in the Arum (Fig. 106), but the spathe in this case is uncoloured.

In some of the Hemlock family (Umbelliferæ) a whorl of bracts occurs at the point where the peduncles originate: this is termed an INVOLUCRE (Fig. 107), while the secondary whorls, occurring at the points where these peduncles branch, are called INVOLUCELS. In plants of the Daisy family (Compositæ, Fig. 108) such whorls also occur, and in their case the individual bracts are called PHYLLARIES. At the base of each of the small flowers constituting a daisy, little bracts called PALEÆ occur. The cup in which the acorn of the Oak is situated, and which is called a CUPULE, is made up of bracts. Bracts also constitute the outer whorl in the flowers of grasses, in which case *they are termed* GLUMES (Fig. 109). In some

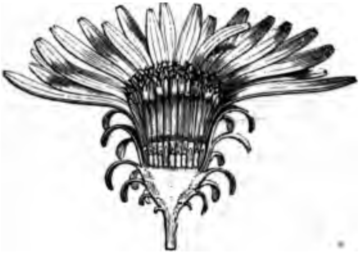
FIG. 107.



Involucre or whorl of bracts in Astrantia.

instances, as in some of the Rose tribe, they for external to the outer covering of the flower

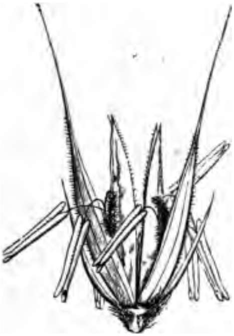
FIG. 108.



Vertical section of a compound flower—Capitulum (A diflora)—showing strap-shaped and tubular florets with whole surrounded by Phyllaries.

called an EPICALYX. In the Strawberry, hov epicalyx is composed of conjoined interpetiolar the adjacent sepals.

FIG. 109.



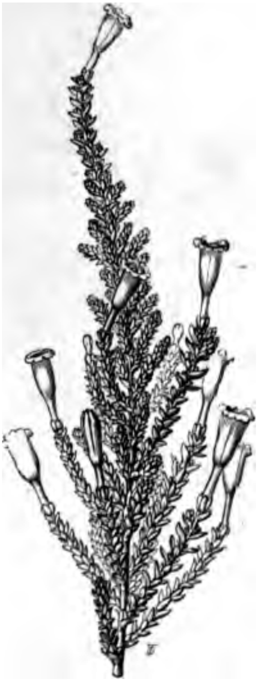
Spikelet of Oat with its Glumes.

Inflorescences.

Each flower terminates an axis, primary or s *whose* development is arrested by the evolutio

-bud. If, therefore, the primary axis be terminated flower-bud, the elongation of that axis must be ed as soon as the bud becomes a flower. If, on the hand, the bud at the extremity of the axis be a ud, that axis may lengthen to an indefinite extent.

FIG. 110.

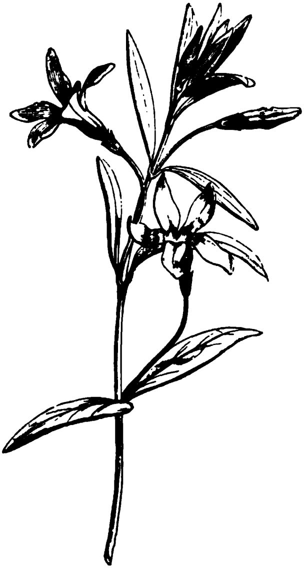


Solitary Terminal Flowers.

ling to the nature of the terminal bud, therefore, scences are divided into DEFINITE and INDEFINITE—*e when the axis ends in a flower-bud; indefinite t is tipped by a leaf-bud.*

n the *primary axis* ends in a leaf-bud, the flower-buds are produced in the axils of the bracts, an lowest being first formed will of course be the oldes the apex of such a plant be looked upon as its centr flowers in all indefinite inflorescences will be deve from the circumference towards the centre, in words, they will be CENTRIPETAL. Again, in the ca the Definite Inflorescence, the terminal bud is ev before all others, which when they originate at all,

FIG. 111.



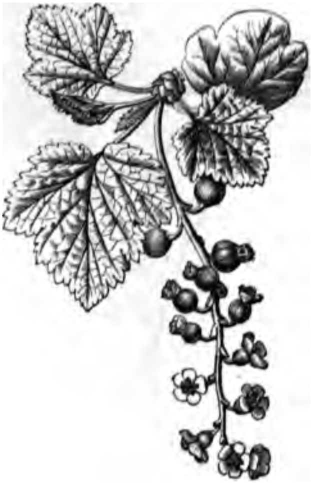
Solitary Axillary Flowers.

in the axils of bracts, below the terminal bud, ar therefore developed from the centre, towards the ci ference, or in a CENTRIFUGAL manner. In using terms, therefore, CENTRIPETAL corresponds witl DEFINITE, and CENTRIFUGAL with DEFINITE.

The terms centripetal and *centrifugal* will be *easily understood* by referring to such a flattene s is seen in the Daisy: if the flowers in the rst developed, and those towards the cir- afterwards, the inflorescence will be *cen-* it if the flowers at the circumference be efore those at the centre, the inflorescence *ipetal.*

: INFLORESCENCES.—As the typical condition o have a stalk, so is it with the flower. It re, be most convenient, in considering the

FIG. 112.

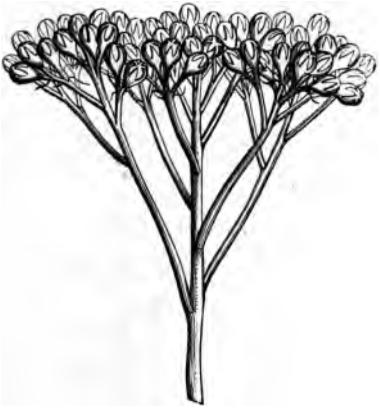


Raceme (Currant).

ls of inflorescence, to consider, first of all, flowers have stalks rather than otherwise. ıg the primary axis, or along secondary axes, 'ers originating in the axils of bracts take hilst the stalks are nearly of an equal length, of inflorescence is called a RACEME (Fig. 112). typical form of the indefinite inflorescence, exemplified in the Currant. When, instead ' *single flowers,* the rachis gives off branches supporting several flowers, the raceme becomes a CLE, as in the Oak. More shortly, the PANICLE mig defined as a *compound raceme.* A slight modificati this, where the branches are short and thick, bu ficiently elongated at the lower part to give the wh pyramidal figure, occurs in the Horse-chestnut, a called a THYRSUS.

If, again, the lower pedicels of the raceme be so elongated as to bring all the flowers to about the level, a CORYMB (Fig. 113) is produced. A very go

FIG. 113.



Corymb (Compound).

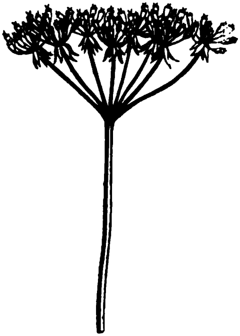
ample of the corymb is afforded by cauliflower in th in which it is eaten; but in this, as in many other the corymb on further development becomes a R as in the same plant when allowed to run to seed.

If now it be supposed that the internodes separate the individual pedicels are suppressed, bri the origins of all the flower-stalks to the same level which they radiate like the rays of an umbrella, th becomes an UMBEL (Fig. 114).

Sometimes it happens that the peduncles thus *nating again* branch in the same manner, and the seco umbels are called UMBELLULES (Fig. 114). Examples of this form occur in plants belonging to the hemlock order (Umbelliferæ).

There are certain kinds of indefinite inflorescences where the flowers are *sessile* (without stalks) instead of being *pedunculate* (stalked). Thus, if the Raceme had no flower-stalks, it would become a SPIKE (Fig. 115), as is seen in the Common Plantain, so that the spike might be defined as *a raceme with sessile flowers.* When the axis is thick, fleshy, and surrounded by a spathe, the spike becomes a SPADIX (Fig. 116), as in the Arum family. When it is composed of unisexual flowers, and falls early (caducous), it is called an AMENTUM, or CATKIN (Fig. 117), as in the Willow. Two other modifications of the spike known as the CONE (Fig. 118) and the STROBILE, the former occurring in Pines, the latter in the Hop, differ from each other in having the scales or bracts *woody* in the cone and *membranaceous* in the strobile. The flowers situated in the axils of these bracts are female in both cases. That form of spike which occurs among grasses is sometimes distinguished as a LOCUSTA.

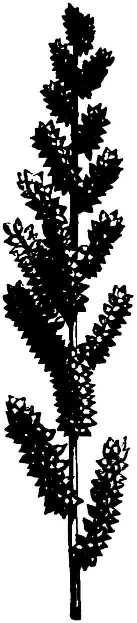
FIG. 114.



Umbel (Compound).

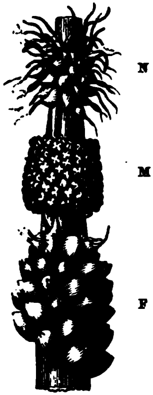
If the axis of the spike be supposed to be developed horizontally instead of vertically, so as to represent a more or less flattened plane, instead of an elongated rachis, the *spike will become a* CAPITULUM, or HEAD (Fig. 119), as is seen in the Daisy and other Compositæ. The flore are sometimes all of the same kind, as in the Dandelio sometimes of two kinds, as in the Daisy; in the latt case, those at the centre are called *florets of the disc*, tho at the circumference *florets of the ray* (Fig. 119).

FIG. 115.



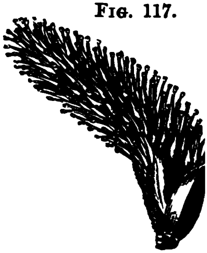
Spike (Compound).

FIG. 116.



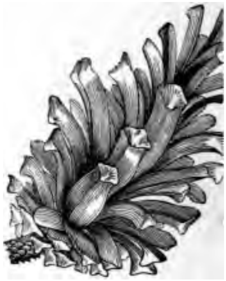
Spadix of Arum maculatum.
N, Neuter flowers;
M, Male flowers;
F, Female flowers.

FIG. 117.



Catkin of the Willow.

FIG. 118.



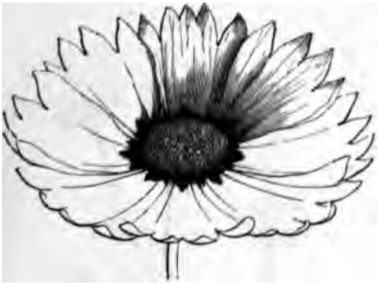
Cone (Pinus sylvestris).

The capitulum bears the same relation to the spike th the umbel does to the raceme or corymb.

DEFINITE INFLORESCENCE.—Where the terminal bud a flower-bud, it is developed before any other on the san axis. This is the grand characteristic of the Definite I *florescence.*

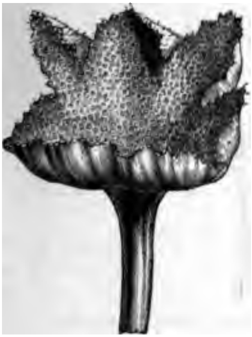
The CYME (*Fig.* 123) is a general term, applied to almo every arrangement of flowers developing in a centrifugal manner. The cyme may simulate almost any of the indefinite forms, more especially the Raceme, Panicle, and Corymb. In the Dorstenia the axis forms a broad, cup-like plate instead of a closed cavity. To this—a sort of definite Capitulum—a special term is applied, viz., COENANTHIUM (Fig. 120). *An* example of it also occurs in the *Fig, where the fleshy* part is the receptacle, and the

FIG. 119.



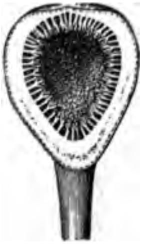
Capitulum, showing florets of the ray and florets of the disc.

FIG. 120.



Inflorescence of Dorstenia contrayerva.

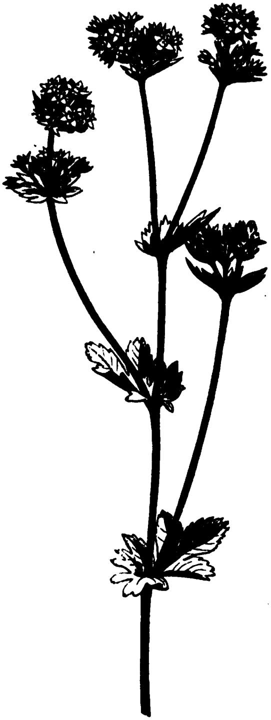
FIG. 121.



Coenanthium (Fig).

small seeds are each the product of a distinct floret. A c
of nearly sessile flowers, such as occurs in the Sweet
liam, is called a FASCICLE; if still more condensed,
flowers constitute a GLOMERULUS. If these last be sc

FIG. 122.



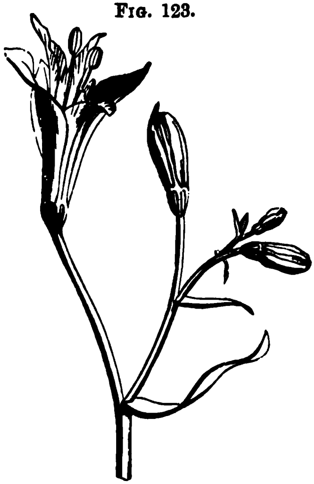
False dichotomy of Alchemilla (compare Fig. 22).

ranged, in the axils of opposite leaves, as to rese
whorls, they constitute VERTICILLASTERS, or FALSE WH
Cymes are of two kinds, the UNIPAROUS CYME and
BIPAROUS CYME. By the growth of these cymes ar

pearance of dichotomy may be given to the stem when there is no such arrangement (Fig. 122).

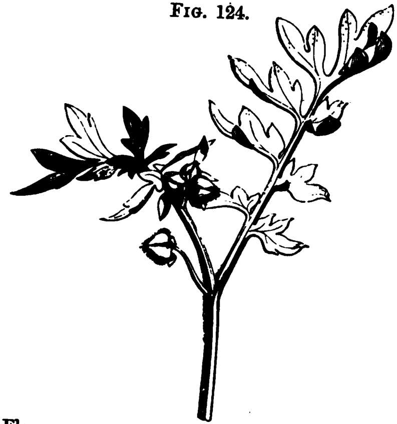
When the secondary buds which appear below the terminal bud are developed on one side of the axis only, a UNIPAROUS CYME is produced (Fig. 123). It sometimes happens that an axis which should end in a flower-bud appears to be prolonged beyond it, and to have the flower-bud developed on its side. This effect is produced by a bud being developed in the axil of a bract a little below the terminal bud, and the new axis thus developed appearing to continue the axis, not to spring from its side. As the buds which continue the axis (for the same process may be repeated again and again), must arise between the flower and the bract, the flowers appear to be arranged on one side of the false axis and the leaves on the other. This arrangement is seen in the Hyoscyamus (Fig. 125). In many instances, however, the new axis forms a distinct angle *with the old one, which,* when frequently repeate

FIG. 123.



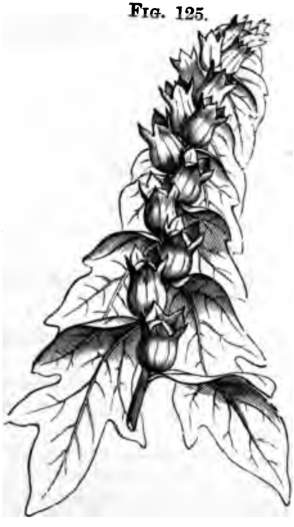
Uniparous Helicoid Cyme (Alstromeria versicolor).

FIG. 124.



Flowers apparently growing *opposite* leaves.

FIG. 125.



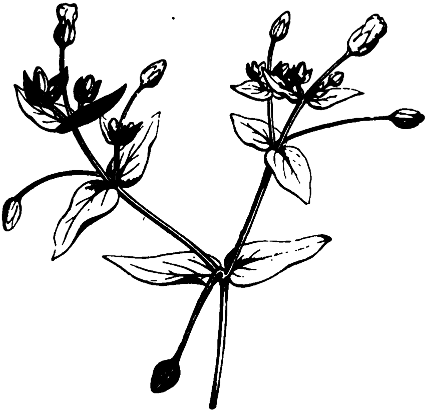
Uniparous Scorpioid Cyme (Hyoscyamus).

makes the inflorescence assume a circinate appearance (Fig. 123). This last variety is called in England either a SCORPIOID or HELICOID cyme, but some French authors restrict the term Scorpioid to such inflorescences as have been described in the Hyoscyamus.

In a BIPAROUS CYME (Fig. 126), the new axes are produced on both sides, as in many of the Chickweed family (Caryophyllaceæ). Such inflorescences may come to simulate one or other of the indefinite forms.

The inflorescence of a plant is not always of the *simple* kind just described: thus spikes may be *compound* (Fig. 115), racemes may give off other racemes, and so on.

FIG. 126.

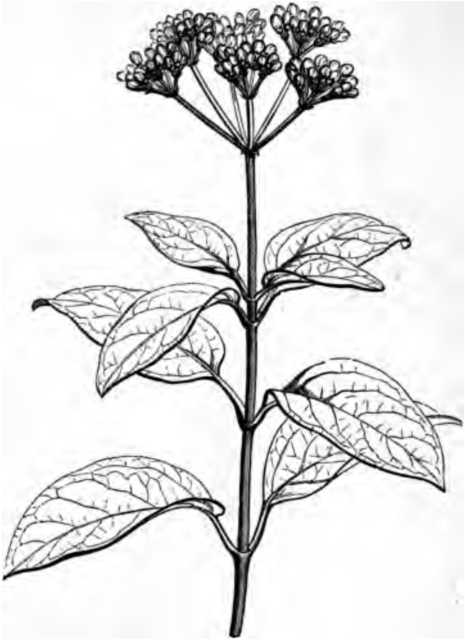


Biparous Cyme (Alsine).

It also occasionally happens that the inflorescences are *mixed* (Fig. 127); thus in the Compositæ, the florets in the *Capitula* are developed *centripetally*, while the capitula are themselves developed on the axis in a *centrifugal* manner, i.e., from below upwards. In the Labiatæ again, the glomeruli, or clusters of flowers, are definite, while the axis of the plant is indefinite, that is, terminated by a leaf-bud.

ANOMALOUS INFLORESCENCES.—There are certain forms *of inflorescence, which* cannot readily be assigned to any of the preceding types. Thus in the Lime-tree (Tili (Fig. 128), and in the Butcher's Broom (Ruscus) (Fig. 130 the flowers appear to rise from the centre of the blade a leaf, instead of in its axil, but the cause of this is widel different in the two cases. In the Lime, the peduncl

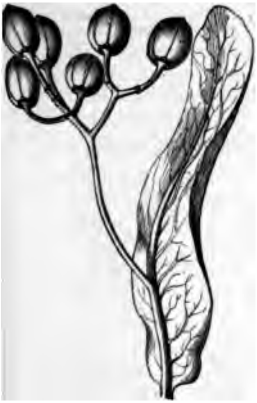
FIG. 127.



Mixed inflorescence: Umbel of Biparous Cyme (Viburnum).

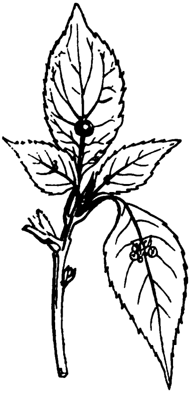
adheres to the petiole of its subtending bract, till it reache the centre of the leaf, where it becomes erect. In Ruscus again, the part which simulates a leaf is really a flatten branch, from which the flower-bud is developed, in th axil of a small membranaceous bract. Closely resemblin this, but differing totally in character, is the inflorescenc

FIG. 128.



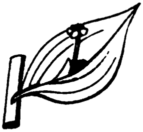
Epiphyllous inflorescence of Lime or Linden tree (Tilia).

FIG. 129.



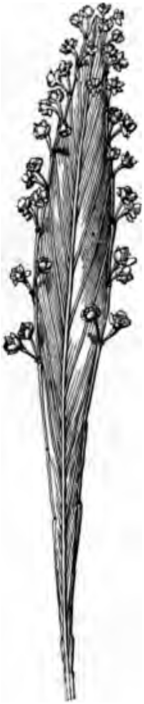
Epiphyllous inflorescence of *Helwingia rusciflora.*

FIG. 130.



Butcher's Broom (Ruscus).

FIG. 131.

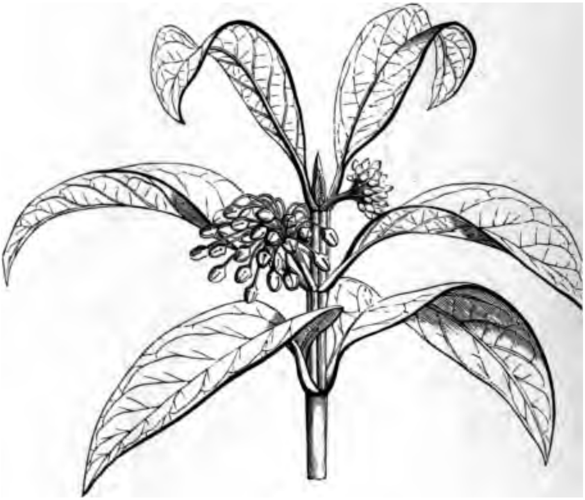


Flattened branch, with flowers of *Zyllophylla* obovata, simulating an Epiphyllous inflorescence.

of Helwingia rusciflora, where the peduncle adheres to t petiole, as in the Linden.

A somewhat analogous inflorescence occurs in Zyll phylla, where, however, the flowers originate on the edg of the pseudo-leaf. This leaf-like organ is probably flattened branch, though some look upon it as a numb of leaves fused together, something like what occurs the flower of the Cockscomb, and which is called *fasciatio*

Fig. 132.



Apparently anomalous (interfoliaceous) inflorescence of Asclepias floribunda, due to the adhesion of the peduncles to the main axis.

Duration.—As to duration, Inflorescences are eith *caducous* when they fall early; *deciduous* when they fa as the fruit begins to ripen; or *persistent* if they remai attached to the ripe fruit. Sometimes, as in the Cashe nut plant, the peduncle becomes enlarged and flesh *during the* ripening of the fruit; it is then said to *EXCRESCENT.*

TABLE OF THE FORMS OF INFLORESCENCE.

Indefinite Inflorescence, where the ***terminal bud is a leaf-bud.***
Definite Inflorescence, where the ***terminal bud is a flower-bud.***
Centripetal = Indefinite, where the lowest or outer flowers are first developed.
Centrifugal = Definite, where the (organically) highest or central flower is first developed.

Indefinite Forms: A. ***Flowers supported on stalks.***

1. **Raceme** = a rachis supporting stalked flowers, with stalks of nearly equal lengths.
2. **Panicle** = a compound raceme.
3. **Thyrsus** = a dense pyramidal panicle.
4. **Corymb** = a raceme with the lower flower-stalks lengthened so as to bring all the flowers nearly to the same level.
5. **Umbel** = a raceme or corymb with suppressed internodes.

B. ***Flowers without stalks.***

1. Spike = raceme with sessile flowers.
   a. Amentum = a caducous spike.
   b. Spadix = a spike with fleshy axis.
   c. Cone = a spike chiefly composed of woody bracts.
   d. Strobile = a spike chiefly composed of membranaceous bracts.
   e. Locusta = compound spike of grasses.
2. Capitulum = a spike with suppressed internodes.

The Definite form of Inflorescence is the **Cyme.**

A. ***Biparous*** cyme, where flowers arise on both sides of the axis.
B. ***Uniparous*** cyme, where flower-buds arise on one side of the axis only.

α. ***Scorpioid,*** where the axis appears continuous.
β. ***Helicoid,*** where the axis is evidently interrupted.

Fasciculus = a contracted cyme.
Glomerulus = a still denser axillary cyme.
Cornanthium = a sessile cyme with suppressed internodes—a definite capitulum.

OFFICINAL FLOWERS.

Kousso—dried flowers of Brayera anthelmintica	Anthelmintic.
Caryophyllus—unexpanded flower-buds of Caryophyllus aromaticus (Clove)	Stimulant and Carminative.
Sambucus—recent flower of Sambucus niger	Slightly Stimulant.
Santonica—unexpanded florets of Artemisia Santonica, yield Santoninum (officinal)	Anthelmintic for round worms.
Anthemis—dried flowers of *Anthemis* nobilis	Tonic and Alkaline.

Lupulus—dried strobile of Humulus Lupulus (Hop)	Sedative.
Ammoniacum—gum resin, chiefly from pedicles of Dorema Ammoniacum	Stimulant and Ex
Cannabis Indica—flowering tops of Cannabis Sativa, growing in India	Sedative & Antis
Oleum Lavandulæ—oil distilled from flowers of Lavandula vera	Stimulant and Ca
Aurantii Floris Aqua—water distilled from the flowers of Citrus Bigaradia and Citrus Aurantium	Aromatic.

CHAPTER VI.

MORPHOLOGY.

THE FLOWER.

THE Flower may be defined *as a number (usually four) of whorls of leaves, modified for the reproduction of the species, and situated at the extremity of an axis, whose internodes at that point are but slightly, if at all, developed.*

The identity of the flower and leaf was first made out by Goethe, and has since been abundantly proved by *Teratology* (study of abnormalities), *Comparative Anatomy, and Development. Teratology* shows that any part of a flower may be converted into a leaf. *Comparative Anatomy* shows that the structure of the one passes into that of the other by insensible gradations; *development* shows that flower leaves and ordinary leaves originate and grow in exactly the same way.

The top of the flower-stalk, which is termed the RECEPTACLE, *Torus*, or *Thalamus*, is often modified for the reception of the parts of the flower by lateral expansion, so as to become a flattened plane, as in the Dandelion, or a cup-shaped cavity, as in the Dorstenia (Fig. 120).

The *whorls of modified leaves* which constitute the *flower* are usually four in number, and, as in ordinary verticillate leaves, the adjoining whorls decussate. The outermost of these rows is called the CALYX, the next one the COROLLA, the individual organs composing these being respectively denominated SEPALS and PETALS. Sepals more nearly approximate the true leaf type than do petals, but in both it can be readily recognised. Most frequently the calyx is *green*, whilst the corolla is of a different hue; as green is not considered a colour in botany, the corolla is said to be *coloured*, and is that part which is popularly known as the flower. Though present in most plants, these two whorls are not found in all, and not being absolutely necessary for the propagation of the species, are known as the NON-ESSENTIAL, or PROTECTIVE organs of reproduction.

Within the corolla stand two other whorls constituting the ESSENTIAL *ORGANS* of reproduction—the one of the male, the other of the female sex. The former is called the ANDRÆCIUM, the latter the GYNÆCIUM. The individual organs of the former are called STAMENS, those of the latter PISTILS, or sometimes CARPELS.

In Dicotyledonous plants it is usual to find 5 *sepals*, 5 *petals*, 5 *or* 10 *stamens*, and 5 *pistils;* while Monocotyledons most frequently possess 3 *sepals*, 3 *petals*, 3 *or* 6 *stamens*, and 3 *pistils*. In Dicotyledonous flowers other figures are often found as the prevailing number. The prevailing number (3) is much more constant in Monocotyledons than in Dicotyledons.

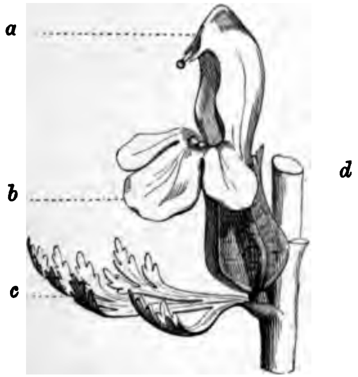
Such is the constitution of the flower, but many exceptions will be found to this its typical structure.

RELATIVE POSITION OF THE PARTS OF THE FLOWER.

In descriptive botany, the terms ANTERIOR and POSTERIOR, SUPERIOR and INFERIOR, are often used with regard to parts of the flower, and it is necessary that the student should make himself acquainted with the meaning of these terms, which at first are very apt to puzzle him.

Flowers are either terminal or axillary, but both kinds are supposed to be subtended by, that is to rise from, the axil of a bract. In the case of the terminal flower the bract immediately below it is looked upon as being that in whose axil it stands. It has already been mentioned that the alternate whorls constituting the flower decussate, and the same law is found to hold good with the bract as with the parts of the flower proper. In those cases where the bracts form a whorl outside the calyx the individual organs will be found to alternate with the sepals, that is to fit into the intervals between them. This alternation is seen even though the bract be solitary, as it generally is. In this last case two sepals stand, the one to the right and the other to the left of the solitary bract. If, therefore, the calyx be composed of five sepals, arranged in a circle, it is evident that the odd sepal will be as far away from the bract as possible. Further, by the law of alternation the corolla is so arranged that two petals stand to the right and left of this odd sepal. If, therefore, the number of petals in the flower be five, and they be arranged like the sepals, it is evident that the odd *petal* will be as far away from the odd sepal—in other *words, as* close to the bract as possible. The same arrangement prevails in the case of the stamens and pistils, so that the odd stamen is as far away from the bract as possible, while the odd pistil is as close to it as it can get.

FIG. 133.



Labiate flower (Pedicularis). *a*, Posterior or Superior part of flower; *b*, Anterior or Inferior portion; *c*, Bract; *d*, Axis.

In describing the position of a flower, it is held so that the bract is next the person examining it, and the stem farthest from him. Thus the bract is ANTERIOR and the stem is POSTERIOR (Figs. 133 and 134). When the bract and

FIG. 134.

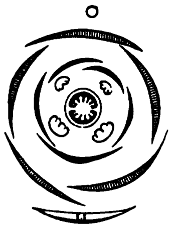


Diagram of the flower of *Pedicularis*, showing the use of the *terms anterior and posterior*, superior and inferior.

the flower are placed horizontally on the plant, that part of the flower next the bract is called INFERIOR instead of ANTERIOR; and the part farthest from it SUPERIOR instead of POSTERIOR. In these two sets of terms, therefore, *superior* may be substituted for *posterior*, and *inferior* for *anterior*. From this it will be seen that the *odd bract* is ANTERIOR, the *odd sepal* POSTERIOR; the *odd petal* ANTERIOR, the *odd stamen* POSTERIOR, and the *odd pistil* ANTERIOR in the normal condition of the flower. The importance of giving attention to position may be shown by the fact that one of the chief means of distinguishing the Rose family (Rosaceæ), from the Pea family (Leguminosæ), is by the position of the odd sepal; in the case of the Rosaceæ the odd sepal is posterior, in the Leguminosæ it is anterior; thus too the odd pistil in the Rosaceæ is anterior and in the Leguminosæ posterior. Except in the case of the Leguminosæ, whenever there is only one pistil, it may be assumed to be anterior, so that the relative position of all other organs may be readily made out from it.

Variations in the Flower.

What a flower is in its typical condition it has all its parts arranged as has already been described, but there are many modifications.

I. When the flower has *all* of the four usual whorls it is said to be COMPLETE.

II. When it has the *same, or multiple of the same numbers of parts* in each whorl, it it said to be SYMMETRICAL; and

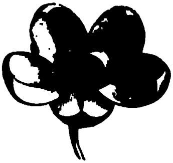
III. When it has every part in the same whorl *identical, as to size, shape, and colour*, it is said to be REGULAR.

I. COMPLETE AND INCOMPLETE FLOWERS.

1. PROTECTING ORGANS.—When both calyx and corolla are present, as is usually the case, the flower is said to be DICHLAMYDEOUS. Should one of these whorls be wanting, this absent one is assumed to be the *corolla*, so that the solitary remaining whorl is called the *calyx*. More frequently, however, in such a case the term *PERIANTH* is used instead of *calyx* (Figs. 135 and 136). *Unfortunately*, the word PERIANTH, or PERIGONE, is some-

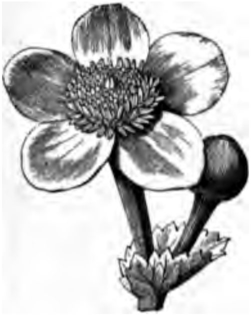
times employed in a different signification. Should the calyx and corolla be coloured alike, whether both whorls be green (*sepaloid*) as in the Dock, or both coloured (*petaloid*) as in the Tulip, the word perianth is used to designate the *double whorl* (Fig. 137). It is sometimes also used to indicate the calyx and corolla collectively, even though there be no peculiarity in their condition.

FIG. 135.



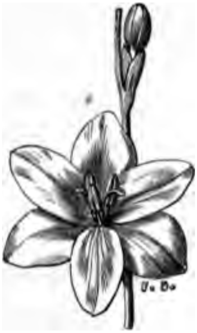
Flower of Deeringia. The perianth is single and sepaloid.

FIG. 136.



Flower of Caltha. The perianth is single and coloured.

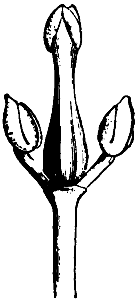
FIG. 137.



Flower of *Sisyrinchium*. The perianth is double, *the whorls being* of the same colour.

When the flower possesses only one whorl of pro organs it is said to be MONOCHLAMYDEOUS, while be absent the term ACHLAMYDEOUS, or NAKED (Fig.

FIG. 138.

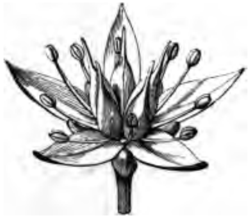


Naked flower (Ash).

used. When the corolla is wanting, the flower i times said to be APETALOUS.

2. ESSENTIAL ORGANS. — When stamens and occur in the same flower, it is said to be PERFECT o MAPHRODITE, which is denoted by the symbol ☿. only one kind of essential organ be present, the fl

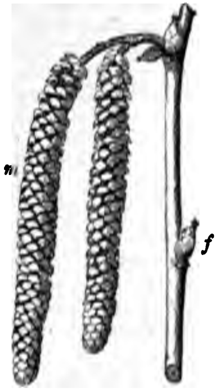
FIG. 139.



Complete and perfect flower (Sedum).

said to be IMPERFECT, or better DICLINOUS. A *which contains* stamens alone is called a MALE *MINATE flower* (indicated by the symbol ♂). Tha

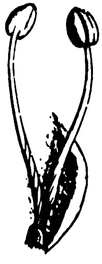
FIG. 140.



Monœcious flowers. Male (*m*) and female (*f*) on the same plant.

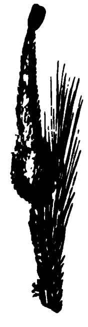
ntains pistils only is said to be FEMALE OR PISTILLATE, nd is indicated by the symbol ♀. To denote a plant hich has both male and female flowers on the same lant, as in the Oak, Birch, &c., the term MONŒCIOUS is

FIG. 141.



Single Male *flower of the Willow.*

FIG. 142.



Single Female flower of the Willow.

used. If they exist on different plants, as in the Willo the flowers are said to be Diœcious. If both male, femal and hermaphrodite flowers occur on one plant, it is sa to be Polygamous. Occasionally NEUTER flowers, or suc as have no sexual organs, occur, as in the outer whor of the Capitula of some Compositæ.

II. Symmetrical and Unsymmetrical Flowers.

When, in a flower, the same number, or a multiple that number, obtains in all its whorls, that flower is sai to be SYMMETRICAL; but when it has one number organs (say five) in one whorl, and another number, nc commensurable with the former (say seven) in another is said to be UNSYMMETRICAL. Irregularity as to numbe in the Pistilline whorl does not interfere with the SYMMETRY of the flower; should it, however, have the sam number of parts as the other whorls, the flower is said t be Isomerous; if not, the flower is Anisomerous.

Fig. 143.

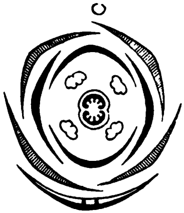


Diagram of a symmetrical flower. Symmetry Quaternary.

When there are only two organs in a whorl, the *symmetry* is said to be Binary or Dimerous; when three Ternary or Trimerous; when four, Quaternary or Tetramerous; and when five, Quinary or Pentamerous. A already mentioned, Ternary symmetry is most commo among *Monocotyledons*, while the *Quinary* prevail among Dicotyledons.

Seeing that flowers are composed of modified leaves, i *might be* anticipated that the ordinary laws of Phyllotax *would apply* to the former as well as the latter. When flower has a binary symmetry—that is to say, has its whorls composed of organs, the number of which is either two, or a multiple of two, such a symmetry might be brought about in accordance with either of the two types of Phyllotaxy—viz., the Alternate or the Whorled. Thus, the outer whorl consisting of two leaf-like organs, might be supposed to be made up of two modified leaves, one on either side of the axis, but either on the same level (opposite), or though on different levels (alternate), the one reduced nearly to the level of the other by the partial suppression of its separating internode. On the former supposition, the leaves would belong to the *opposite* type, on the latter to the *alternate* type, and being separated by the whole width of the axis, might be said to be arranged in the one-half, or distichous manner. The same holds good with the other whorls. So again were the symmetry ternary, each whorl might be supposed to be made up of modified verticillate leaves, three in a whorl, or of alternate leaves arranged in the tristichous (one-third) manner, with two shortened internodes to each whorl.

If flowers be composed of alternate leaves with shortened internodes, it is difficult to account for the decussation of the different whorls, except by supposing the leaf spirals to be *Heterodromous.*

On the other hand, were flowers composed of truly whorled leaves, all the leaves should originate on the same level; but in flowers whose buds have an imbricate arrangement, this is not the case, for there some leaves are nearer the centre or organic apex than others. To account for this, M. A. de Jussieu supposed that the floral organs in imbricate buds, with trimerous or pentamerous symmetry, were placed according to the five-thirteenth arrangement. Were such the case, the slightest tendency of the parts to develop to either side would produce a decussation of the whorls.

III. REGULAR AND IRREGULAR FLOWERS.

By a REGULAR flower is meant, *one which has each of its whorls composed of organs of the same* SIZE, *the same* SHAPE, *and the same* COLOUR. Irregularity may therefore refer to any or either of these particulars: examples will be given further on.

Variations from the Typical Condition of the Fl

I. The completeness of a flower can be altered
way only—*i.e.*, it may be made incomplete (*a*) b
morphosis, (*β*) by suppression or abortion.

II. The symmetry of a flower may be destroyed
ways—viz., by increase or diminution of parts—
parts of a flower may be multiplied (*a*) by metamo
(*β*) by splitting (Chorisis or Dedoublement).
parts of a flower may be diminished (*a*) by m
phosis, by (*β*) suppression or abortion, (*γ*) by a
and cohesion.

III. Irregularity may be produced by (*a*) irreg
hesion, or by (*β*) irregular development.

1. Metamorphosis of one kind of organ into an
very common; for seeing that all the floral org
merely modified leaves, it might be easily imagin
any one of them could be converted back again
true leaf, and such is really the case.

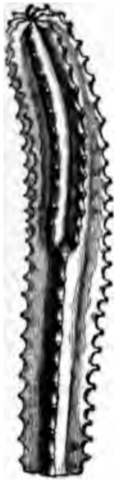
Again, a more highly developed organ may be c
into a lower, as a stamen into a petal, an organ o
degree, and so on. Such a change is seen in
flowers, as the Rose, Camellia, &c. This transfo
of a higher organ into a lower is called RETR
METAMORPHOSIS. Of course, there will be a dimin
the parts thus converted into other organs, corres
to the increase of the organs simulated—*ex. gr.*,
instance just given, the number of stamens
lessened in the same ratio as that of the petal
creased.

2. Organs may be also increased in number by
termed CHORISIS or SPLITTING. The term DEDOUB
or UNLINING is applied to the same process, but is
appropriate. There are two kinds of splitting—
Collateral (Fig. 144), the other *Transverse*.
former, the number of organs in a single whor
creased, by the latter the number of whorls is aug

In the Mustard family (Cruciferæ), the flowers
symmetrical, there being six stamens—four long a
short, while there are only four petals. Some b
account for this by supposing that the four long s
are produced by the splitting of two of the normal
(four). This condition is somewhat analogous to
a compound leaf with two leaflets. A similar s

to a less extent, is seen in many other cases, as in
ıls of the Mignonette, which are cut up into
In *transverse* or *vertical Chorisis*, again, the
ears to be split into two layers, and some account
nanner for the position of such stamens as are
pposite to, instead of alternate with, the petals.
rangement, however, rather appears to depend

FIG. 144.



Euphorbium to illustrate Chorisis, one ridge splitting into two.

ıe absence of a whorl of stamens intermediate
those still existing and the inner whorl of petals,
turn of the spiral to its natural condition, so that
ent whorls coincide instead of decussating. In
aryophyllaceæ), at one part of the petal there is
r organ, which, as some think, has been produced
ing, while others suppose it to be composed of
stipules.

PPRESSION AND ABORTION.—The most frequent
diminution as to number is SUPPRESSION, or

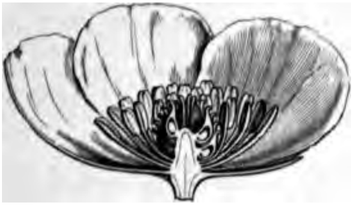
Abortion, the former term implying the *complete absence* of an organ, the latter *its presence, but in an imperfect or rudimentary state.* Organs, such as stamens, in an abortive condition are often called Glands, or Nectaries, though they have no glandular structure.

4. Cohesion.—By cohesion is implied the union, to a greater or less extent, of the parts constituting the same whorl. It is extremely common in all the whorls of the flower. When the calyx is composed of distinct sepals, it is said to be Polysepalous; but when the sepals unite one with another, no matter to how small an extent, it becomes Gamosepalous. The typical condition of the corolla is Polypetalous, but cohesion may render it Gamopetalous, or, as it is sometimes incorrectly called, Monopetalous. Cohesion is rarer in the staminal than in any other whorl; sometimes, however, the stamens do unite one with another, either at their lower parts only, when they are said to be Monadelphous if they form a single bundle, Diadelphous if they constitute two, and Polyadelphous if there be more than two. If union takes place at the upper part *only*, the stamens are said to be Syngenesious. Cohesion of the carpels is very common, and occurs in every degree, from little more than touching at the base, to complete fusion of all the parts. The term used to imply a condition the opposite of coherent is distinct.

5. Adhesion.—By adhesion is meant *the union of parts constituting distinct and different whorls*, as the stamens with the petals, or these latter with the sepals. The opposite condition to *adherent* is indicated by the term free. There are certain terms relative to this condition constantly occurring, and the student will do well to make himself thoroughly acquainted with their meaning; they are Hypogynous, Perigynous, Epigynous, Superior, and Inferior.

In the typical flower all the organs are not only distinct from each other, but each has a separate insertion into the Receptacle. When stamens are inserted below the level of the pistil, they are said to be Hypogynous; when, on the other hand, the three outer whorls become united so as to form a sort of tube called a Calyx tube *before* they reach the receptacle, the stamens are said to be Perigynous. Should, however, the *calyx tube* formed by the adhesion of the sepals, petals, and stamens closely ound and adhere to the pistil, so that no part of it be seen except the top, the stamens are said to be NOUS.

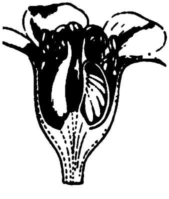
FIG. 145.



Receptacle of Ranunculus—Hypogynous Stamens.

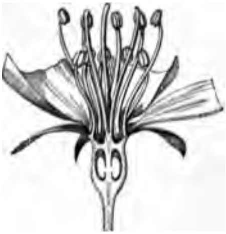
rtain of the great divisions of Dicotyledons are ded on these peculiarities. Thus the THALAMIFLORÆ rehend all flowers with *Hypogynous* stamens, the r whorls being *free* and *distinct*. The CALYCIFLORÆ, n, which have their stamens inserted into the so- d calyx tube, may have either *Perigynous* or *Epigy-* flowers. In the COROLLIFLORÆ, the corolla is Gamo- lous, and the stamens are inserted in it so as to uce a kind of perigynous flower.

FIG. 146.



Superior Ovaries—
'erigynous Stamens.

FIG. 147.



Inferior Ovaries (Apple)—
Epigynous Stamens.

e terms SUPERIOR and INFERIOR are used with d to the *calyx and pistil.* When the calyx is *ior, that is, adherent to* the ovary, and completely

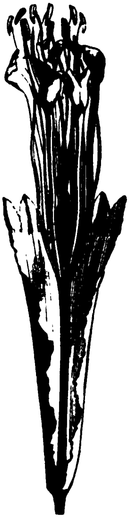
covering it, the latter will of course be *Inferior*. Wl
again, the sepals are *free* and inserted below the ov
the calyx will be *inferior*, the ovary *superior*. O
sionally the term *Half-superior*, or *Half-inferior*, is u
to indicate an intermediate condition. When the stam
adhere to the pistil, as they do in the Orchidaceæ
Asclepiadaceæ, they are termed GYNANDROUS.

The *Unequal development* and *Union* which give
to IRREGULARITY, present nothing worthy of spe
notice.

UNUSUAL CONDITIONS OF THE RECEPTACLE.

Occasionally the extremity of the axis in which
flower is inserted, instead of being small and inc
spicuous, becomes much enlarged, more especially w

FIG. 148.

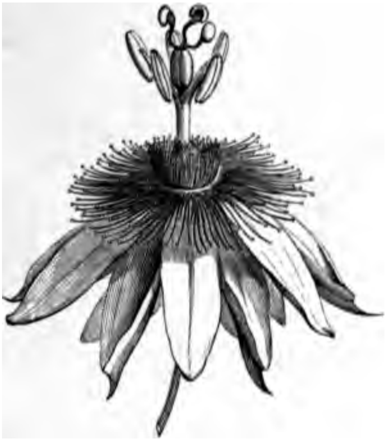


Flower of Silene Italica—calyx torn to show the interv
the insertion of sepals and petals (Anthtopho

istils are numerous. In the Nelumbium it grows up
en the individual carpels, and finally appears to en-
each in a little cavity. The edible part of the Straw-
is the enlarged receptacle, as is in part the fleshy
n of the Hips of the Rose. Sometimes, as in the
ium, the receptacle is prolonged between the ovaries
onsiderable extent.

hough, in their normal state, the internodes sepa-
g the different floral whorls remain undeveloped, yet
s may be found in which one or more of these have

FIG. 149.

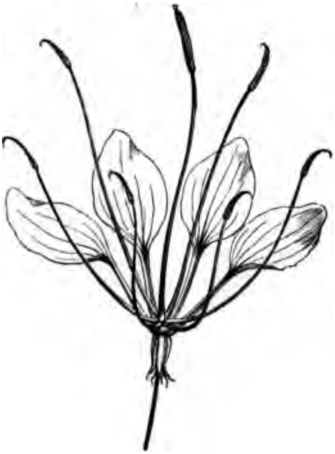


Flower of Passiflora, to show the interval between the insertion of petals and stamens (Gonophore).

lengthened out. This developed internode is called
TIPE, and the organ supported on it is said to be
TATE. Some of the Caper family (as Gynandropsis)
developed internodes between each of the whorls.
n the developed internode occurs between the sepals
petals, it is called an ANTHOPHORE (Fig. 148). When
nternode occurs between the corolla and stamens, it
lled a GONOPHORE. When the developed internode
orts the pistils only it is denominated a GYNOPHORE,

Carpophore, or Gynobase. Sometimes each carpel ported on a separate stalk, which is termed a Thec. This differs from the kind of stalk just mentioned, responding with the petiole of the carpellary leaf b it, rather than with the developed internodes of ceptacle.

Fig. 150.



Flower of Caper plant—the gynæcium far removed from the rest of the flower (Gynophore).

Fig.

Disk (Di

The Disk is a peculiar organ, either produced expansion of the receptacle, or by conjoined which sometimes intervene between the stame pistils. It may be hypogynous as in the Orange, nous as in the Apple, or epigynous as in Umbel Plants.

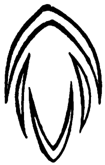
CHAPTER VII.

PRÆFLORATION OR ÆSTIVATION.

HE floral envelopes are arranged in the flower-bud in much
e same way as leaves in the leaf-bud, but there are cer-
in modes of folding found in the flower which are un-
iown in the leaf-bud. Besides the *Reclinate*, and *Circi-*
ite, the *Conduplicate*, *Convolute*, *Plicate*, *Involute*, and
evolute forms of leaf-folding, other modes occur. The
wer-buds of the Poppy and some other flowers, instead
being regularly folded, have their petals irregularly
umpled up. This kind of æstivation is known as the
ORRUGATE or CRUMPLED.

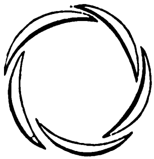
As to the position of the flower-leaves with regard to
ch other, besides the *Imbricate*, *Valvate*, and *Indupli-*

FIG. 152.



Vexillary Æstivation.

FIG. 153.



Contorted Æstivation.

te, other forms are seen. In what is called VEXILLARY
stivation (Fig. 152), seen in Papilionaceous flowers, one
rge piece called the VEXILLUM or STANDARD embraces two
de pieces, or ALÆ, which in their turn enclose two con-
ined petals, forming what is called the CARINA or KEEL.
n the CONTORTED (Fig. 153), called also the CONVOLUTE
rm of æstivation, the principle of the convolute verna-
on, already explained as to single leaves, is applied to
e whole group of flower leaves forming the calyx and
rolla. The leaves appear to radiate from the centre to
e circumference of the flower, and are then twisted
und, *as is done in rolling* up a piece of music or an

umbrella. In Gamopetalous corollas, combined with a sort of plaiting, this is called SUPERVOLUTE, and is seen in the Convolvulus.

Sometimes the calyx and corolla exhibit different modes of æstivation, as in the Mallow family (Malvaceæ), where the *calyx* is arranged in a *valvular*, the *corolla* in a *contorted* manner. In St. John's Wort (Hypericum), &c., the æstivation of the calyx is *imbricate* and that of the corolla *contorted*.

CHAPTER VIII.

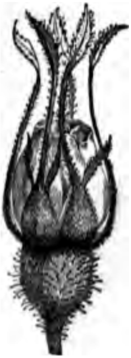
NON-ESSENTIAL FLORAL ORGANS.

PART I.—*Calyx.*

the CALYX is the outermost of the leaf-whorls titute the flower. Sometimes, however, there outside the calyx, usually composed of modi- or stipules of the sepals, and termed an

pical flower the sepals are *distinct* (POLYSEPA- IALYSEPALOUS), but they may cohere either partially, when the calyx is said to be GAMO- MONOSEPALOUS.

FIG. 154.

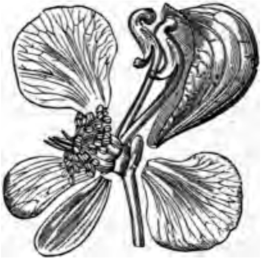


Rosebud showing segmented sepals.

pproach the leaf type more nearly than any e floral organs: usually they are *sessile* and sometimes they are coloured or *petaloid.* In sepals are *entire*, but sometimes the margins in the Rose (Fig. 154). *Irregularity* is often pro- pals by the development of pouches, spurs, &c., *er part.* A curious irregularity exists in the

Aconite, where the sepals are coloured, and form that hood whence the plant's name of *Monkshood* is derived (Fig. 155).

FIG. 155.

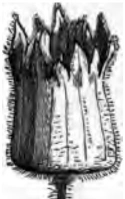


Flower of Aconite—sepals cut away to show irregularity.

Sepals may either stand *erect* or have their free margins turned outwards (*divergent*). If, on the other hand, these free margins are turned inwards, they are said to be *Connivent.*

When the calyx is *gamosepalous*, the union between the individual organs may be either complete or partial. The part where the sepals cohere is called the TUBE, and the upper extremity of this is called the THROAT (FAUX), while the free or spreading portion is called the LIMB. This limb is composed of LOBES or TEETH (Fig. 157), if cohesion is not complete. The spaces which separate the lobes are

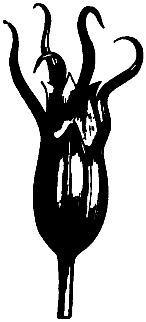
FIG. 156.



Dentate calyx of China Primrose.

USES. If the cohesion be complete, the limb is
e ENTIRE.

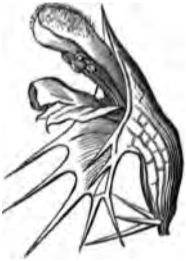
FIG. 157.



alyx of Agrostemma, showing free lobes or teeth.

e sinuses, if they exist, and by the projecting rresponding to the midribs of the true leaves, the of sepals making up such calyces may be ascer· Gamosepalous calyces may be either *regular* or (Fig. 158), and the terms employed to designate

FIG. 158.



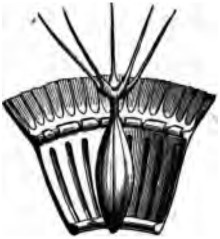
Irregular calyx of a labiate flower.

rent varieties are much the same as those applied *olla, which will be* described hereafter.

DURATION.—As to duration, sepals are either C as in the Escholtzia, where the calyx falls off like tinguisher of a candle; or in the Poppy, where it in the ordinary way, immediately after the expa the flower. They are *deciduous* when they fall o the same time as the corolla, as is the case in most If the sepals remain attached to the ripening fru the Labiatæ, &c.) they are said to be PERSISTENT. calyx remain in a withered state, attached to t but surrounding it loosely, it is said to be MAR Sometimes the calyx continues to grow so as to bladder-like covering to the fruit, as in Physalis then said to be ACCRESCENT.

MODIFICATIONS.—The most important modificatio sepals undergo is into what is termed a PAPPUS (F

FIG. 159.



Pappus—involucre cut to show it.

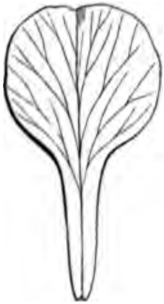
This is seen in the Compositæ, Dipsaceæ, and Valeri In some of these plants the calyx, which, originall its lower part, differs in no respect from the typic towards the period when the fruit ripens, splits u great number of slender thread-like filaments. when the fruit separates from the receptacle, su in the air till a proper resting-place be attained. one has seen examples of this in the *down* of the Dandelion, &c.

PART II.—*Corolla.*

The inner whorl of the floral envelope, whic *resent, is* usually coloured, is called the COR the modified leaves composing it are called PETALS. Though the homology of petals with leaves is less evident than is that of sepals with leaves, still it may be distinctly made out in various ways. First, by the gradual passage of the green sepals into coloured petals, as in the Water-lily, and secondly, by the close analogy between the different parts of leaves and petals as to structure, &c.

Though sepals are usually sessile, such is not always the case with petals, for these often have a narrow contracted part, corresponding to the leaf-stalk, which is termed the CLAW (UNGUIS), whence such petals are said to be UNGUICULATE (Fig. 160). The spreading portion, corresponding to the blade of the leaf, is called the LIMB. Unguiculate petals may be seen in most plants of the Chickweed family (Caryophyllaceæ), as in the Carnation, &c.

FIG. 160.

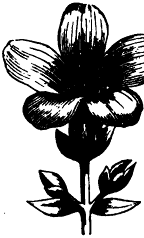


Petal with claw.

The terms used in describing the margin, outline, &c., of leaves are applied with like significations to petals. There are, however, certain conditions peculiar to petals, such as that seen in the Ragged Robin (Lychnis Flos-cuculi), whose petals look as if cut up into fringes, and are said to be LACINIATED or FIMBRIATED (fringed). As to shape, some petals are boat-shaped (NAVICULAR), others spoon-shaped (COCHLEARIFORM), or have processes or pouches of greater or less dimensions projecting from them, hence are said to be GIBBOUS, SACCATE, or SPURRED, *according to the size* and shape of the processes. Y certain cases, more especially when there is mo one whorl of them, some of the petals may be lessened as to size, &c., that is, become *obsolete* (*tive.* The term NECTARY is used to designate th other floral organs in such a condition.

The corolla is usually much more delicate in and of a brighter colour than any other part

FIG. 161.

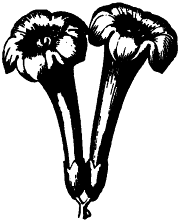


Polypetalous Corolla.

flower. In many cases it is furnished with gla creting odoriferous substances.

As to Cohesion, the corolla may be either POLYP (DIALYPETALOUS) (Fig. 161), or it may be MONOP (GAMOPETALOUS) (Fig. 162). In describing the

FIG. 162.

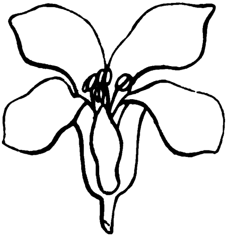


Gamopetalous Corolla.

(GAMOPETALOUS) condition, the terms *tube, throat,* (*and limb,* are used with the same signification a *applied to* the calyx.

POLYPETALOUS COROLLA. A. REGULAR FORMS.—The regular forms of the Polypetalous Corolla are four in number—viz., the CRUCIFORM, CARYOPHYLLACEOUS, ROSACEOUS, and LILIACEOUS.

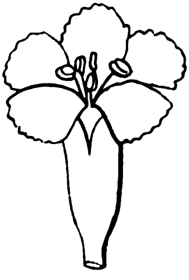
FIG. 163.



Cruciform Corolla.

1. CRUCIFEROUS, OR CRUCIFORM COROLLA.—This kind of corolla gives its name to the family of the Cruciferæ, or Mustard tribe. It consists of four petals, usually unguiculate, arranged in the form of a St. George's cross. Ex. Wallflower, Stock, &c. (Fig. 163).

FIG. 164.

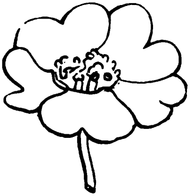


Caryophyllaceous Corolla.

2. CARYOPHYLLACEOUS COROLLA.—This variety, seen in the Chickweed family (Caryophyllaceæ), consists of five petals, *with long claws,* enclosed in the tube of the calyx,

and with limbs diverging almost at right angles fr
claw (Fig. 164). Ex. Lychnis, Pink, Carnation, &
3. **Rosaceous Corolla.**—This form of corolla c
of five petals, whose claws are absent, or only s

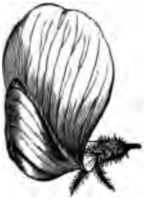
Fig. 165.



Rosaceous Corolla.

developed (*obsolete*), spreading regularly from thei
tion (Fig. 165.) Ex. Strawberry, Single Rose, &c.
4. **Liliaceous Corolla.**—This form differs very
from the Rosaceous' only it belongs to the Mon
donous type. In this the petals form a sort of
before spreading, instead of diverging directly, as
Rosaceous form. Ex. Lily.

Fig. 166.

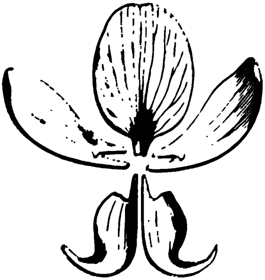


Papilionaceous Corolla.

B. **Irregular Polypetalous Corollas.**—The
regular form occurring among polypetalous cor
which any distinct name has been applied, is
PILIONACEOUS, or *Butterfly-shaped* Corolla, seen
Pea and many other Leguminosæ. The five p
which it is composed are arranged so that the o
which is very large, and called the VEXILLUM, or st

ted posteriorly. At the sides are two pieces he Alæ, or *wings*, while anteriorly two smaller

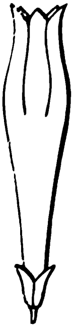
FIG. 167.



Parts composing a Papilionaceous Corolla.

nite to form what is called the CARINA, or *Keel* 66 and 167).

FIG. 168.



Tubular Corolla.

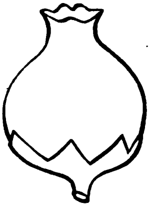
GAMOPETALOUS COROLLA.—The Gamo- s forms of corolla are more numerous e the former, there being *six* regular s—viz., the TUBULAR, the URCEOLATE, MPANULATE, the INFUNDIBULIFORM, the TERIFORM, and the ROTATE; and *three* r—viz., the LABIATE, the PERSONATE, LIGULATE corollas.

EGULAR. 1. The TUBULAR corolla con- a tube nearly cylindrical throughout, e seen in the central flowers of many itæ, &c. (Fig. 168).

he URCEOLATE, OR URN-SHAPED CO- -This is a modification of the former, the tube is expanded at the centre ing somewhat contracted both at the d apex, seen in the Purple Heath &c. (Fig. 169).

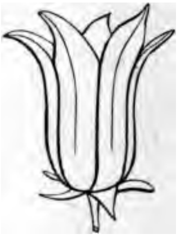
e CAMPANULATE, OR BELL-SHAPED COROLLA.—When e *dilates gradually* and continuously from base to apex, instead of in the middle only, it produces Campanulate corolla seen in the Harebell (Fig. 170).

FIG. 169.



Urceolate Corolla.

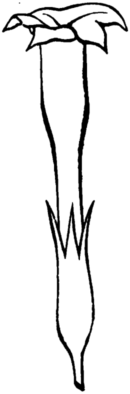
FIG. 170.



Campanulate Corolla.

4. The INFUNDIBULIFORM, OR FUNNEL-SHAPED COROLL This differs from the last variety only in having a l tube, contracted most of the way wards from the base, but with the l dilating gradually at the top, as in flower of the tobacco-plant (Nicot (Fig. 171).

FIG. 171.



Infundibuliform Corolla.

5. The HYPOCRATERIFORM, OR SAL SHAPED COROLLA.—This form differs f the others in having a *long* narrow t from which the limb *suddenly* dive nearly at a right angle. Ex. Phlox, P rose, &c. (Fig. 172).

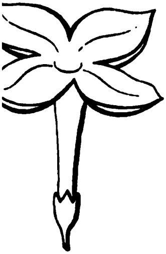
6. The ROTATE, OR WHEEL-SH COROLLA. — This form of corolla di from the last in one respect only, the being *very short,* in fact scarcely per tible, the limb spreading as before. Potato and other Solanaceæ (Fig. 17

B. IRREGULAR GAMOPETALOUS CORO

1. The LABIATE COROLLA. — In the biate, bilabiate, or lipped corolla, the l is divided into two distinct lips. upper, overhanging the lower, is usu composed of two petals more or *united;* the lower, made up of three, may be en *bifid, or* trifid. When the upper lip is much arc

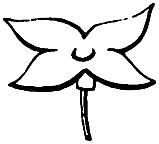
he White Dead Nettle, the corolla is sometimes
be RINGENT or GALEATE. This form of corolla
ts name to the natural family of the Labiatæ, in
t very commonly occurs (Fig. 174).

FIG. 172.



pocrateriform Corolla.

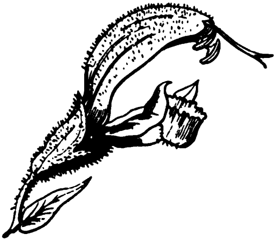
FIG. 173.



Rotate Corolla.

he PERSONATE, OR MASK-SHAPED COROLLA.—This
iffers from the labiate in having the throat par-
ccluded by a bending back of the lower lip, termed
ATE. Ex. Snapdragon (Fig. 175). In Calceolaria

FIG. 174.



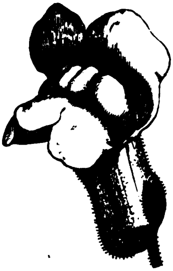
Labiate Corolla.

ghtly modified, so as to resemble a slipper. This
is sometimes called CALCEOLATE.

E LIGULATE, OR STRAP-SHAPED COROLLA.—This kind
la is *simply a tubular* one, partially split up, so as

to become a flattened band, or strap-like body as in the florets of the Dandelion (Taraxacum) outer florets of the Daisy.

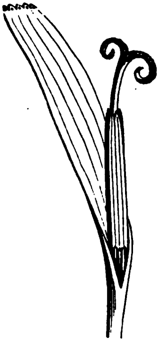
FIG. 175.



Personate Corolla (Antirrhinum).

The number of petals composing such often indicated by incisions, or teeth, at the the strap.

FIG. 176.

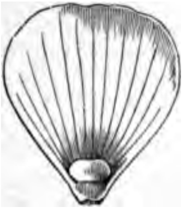


Ligulate Corolla.

Many of these corollas are accompanie *sponding* forms of calyx, as the tubular, labia

:NDAGES OF THE COROLLA.—At the base of the Petals Ranunculus a small scale-like organ is visible, is called a NECTARY (Fig. 177). Similar organs n many other plants. Thus in the Narcissus, they sort of ring (called a *corona*) in the interior of the . A ring of hairs similar to this occurs in the r of the flowers of the Boraginaceæ. The origin of organs has been by some attributed to transverse s; by others, to the abortion of adnate epipetalous ns.

FIG. 177.



Neotariferous Petal (Ranunculus).

:ATION.—The corolla may be *caducous*, *deciduous*, *sistent*, like the calyx. When persistent, it usually s up, and becomes *marcescent*, as in the Heath. In ne, the caducous petals continue to cohere by their and so fall off in the shape of a little star.

OFFICINAL PETALS.

-dried petals of Papaver Rhœas	Colouring agent, slightly Sedative.
ntifolia—fresh petals of R. Cen- lia (Cabbage Rose)..................	Odoriferous.
allica—fresh and dried petals of buds of R. Gallica (Red Rose) .	Astringent.

FORMERLY OFFICINAL.

recent petals of Viola odorata reet Violets)	Colouring agent.

CHAPTER IX.

MORPHOLOGY.

THE ESSENTIAL ORGANS OF REPRODUCTION.

WITHIN the two outer whorls of modified leaves which constitute the *non-essential organs* of Reproduction are placed two other whorls, constituting the *Essential Organs.* The outer of these two whorls composed of *stamens,* is termed the *Andrœcium;* the inner, made up of *pistils,* is called the *Gynœcium.*

PART I.—*Stamens.*

Hitherto the floral organs treated of could with very little difficulty be referred to the ordinary leaf type, but in those which have now to be described there is a greater divergence from that type. The individual organs constituting the *Andrœcium* are termed STAMENS.

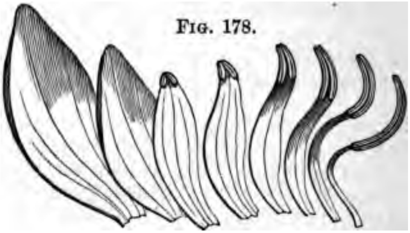


FIG. 178.

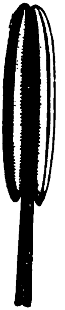
Transition of petals into stamens (Nymphæa).

A stamen might be defined as a *flower-leaf, peculiarly modified for the production of a powdery substance called* POLLEN, *which is necessary for the fecundation of the ovule.*

As the normal condition of the leaf is to be furnished with a stalk, so the stamen usually possesses a thread-like organ homologous with the petiole of the leaf, and termed the FILAMENT. Supported by the filament is *that* part of the stamen corresponding with the blade of *the leaf;* it is called the ANTHER. As in most cases the livided into two equal halves by the midrib, so the is made up of two halves or LOBES. These ond to the halves of the leaf, and are joined ır by the homologue of the midrib, which is called NNECTIVE. The interior of each an- ɔe is occupied by one or more cavi- lled CELLS, or LOCULI, which contain LEN.

EN is homologous with the cellular which makes up the greater part of af, and the cells correspond with the rers of this tissue found in the leaf, l afterwards be described. Some ıts suppose that the anther is formed anner somewhat different from that escribed. They hold that in it the folded, so that its two margins meet connective. On this theory the whole surface of the anther would corre- with the lower surface of the blade leaf, and not partly with the upper, with the lower, as on the other hypo- The former doctrine, which main- hat there is no folding whatever, is ırobably the correct one.

FIG. 179.



Longitudinal Dehiscence of an Innate Anther.

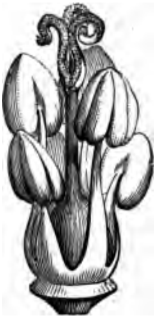
ıgh commonly present, the filament is not abso- necessary, and is sometimes absent, in which case ther, like a leaf without a petiole, is said to be The base of the filament is usually attached to ceptacle by a joint, which, however, may not be nt when there is adhesion of the stamens to either outer whorls. Occasionally the staminal filament loped without any anther, when it is said to be :. Sometimes the stamen exists as a scale, or a protuberance merely, when it is called a STAMI-

MENT.—In most cases the filament is a slender ·like organ, hence called *filiform*,—or hair-like, med *capillary*. It may taper from base to apex, it is said to be *awl-shaped*, or *subulate;* or from o base, when it is called *clavate*, or *club-shaped*. mes, as in the Nettle, it resembles a row of beads *form*); or it may be *petaloid*, as in the Water here *there are organs* in every stage intermediate

between a perfect petal and a perfect stamen (Fig
Occasionally it is divided at the summit into two o
teeth, one or all of which may support anthers. I
cases appendicular organs, probably homologou
stipules, are found at the base of the filament i
shape of glandular processes, as in the Lauraceæ
spurs in Rosemary, &c.

ANTHER.—The usual shape of the anther is son
oblong, with a furrow on one surface (the FACE),
ridge on the other (the DORSUM, or back). These
spond with the Connective. At the border corresp
with the edge of the leaf is a sort of line, at wh

FIG. 180.



Extrorse Stamens.

ripe anther usually opens, called the SUTURE. Wh
face of the stamen is turned towards the pistil
wards, as is usually the case, the anthers are sai
INTRORSE; but when the face looks outwards, or t
the petals, they are said to be EXTRORSE (Fig. 180).

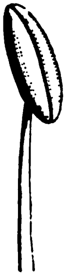
There are three principal ways in which the fila
joined on to the anther: these are the INNATE, A
and VERSATILE.

1. INNATE.—When the filament appears to pass
into the connective without any interruption, the
is said to be INNATE (Fig. 179).

2. ADNATE.—When the filament does not pass
into the base of the connective, but appears to

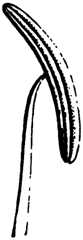
the back of it at, or not far from the base, and then to be continued along the connective, the anther is said to be ADNATE (Fig. 181).

FIG. 181.



Adnate Anther.

FIG. 182.



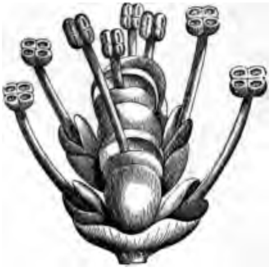
Versatile Anther.

3. VERSATILE.—When the filament joins the connective near the middle of the latter, so that the anther appears balanced on a fine point, it is said to be VERSATILE (Fig. 182).

CONNECTIVE.—In most cases the connective is a solid body, uniting the two adjacent anther-lobes, and neither extending beyond nor falling short of their extremities. Occasionally the connective is developed beyond the anther-lobes, as in the Oleander, &c.; and on the other hand, it may not reach their extremities, producing an *emarginate* appearance. Sometimes the connective has a decided lateral development, separating the one anther-lobe from the other. When this is very marked, the anthers are said to be DISTRACTILE, as in the Sage, &c. When furnished with appendages (spurs, &c.), the anther is said to be APPENDICULATE. When the anther-lobes are very long and narrow, as in the Grasses, they are said to be LINEAR. In the Cucurbitaceæ they are very much convoluted (SINUATE), so as to resemble a sort of scroll.

In their young state the anthers usually contain four cavities, or LOCULI (hence termed QUADRILOCULAR) (Fig. 183), but by the absorption of the septum in each lobe, when ripe they *usually possess but* two (BILOCULAR). In a few instances the connective also becomes absorbed, so as to leave but a single cavity, in which case they are said to be UNILOCULAR. When only one lobe is developed, the anther is said to be DIMIDIATE.

FIG. 183.



Quadrilocular Anthers.

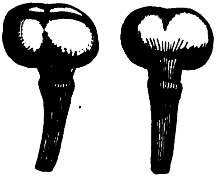
DEHISCENCE.—As the function of stamens is the production of pollen, which, to be of any service to the plant, must make its way to the pistil, there must be some contrivance for its escape from the anther. This is effected by what is termed the DEHISCENCE, or bursting of the anther, which takes place according to one or other of four plans—viz., by LONGITUDINAL, TRANSVERSE, POROUS, or VALVULAR Dehiscence.

1. LONGITUDINAL DEHISCENCE.—When the pollen is fit for fecundation, the anther often bursts in the marginal line already mentioned, and called the *suture*, which corresponds with the margin of the blade of the leaf. This constitutes LONGITUDINAL dehiscence (Fig. 179). Ex. Ranunculus.

2. TRANSVERSE DEHISCENCE.—Though the anther-lobes are generally placed parallel with the connective, yet, in a few cases, they are twisted on their own axes, so that their bases or apices, instead of their sides, are directed towards it. Should this be the case, it will be readily understood that dehiscence taking place along the margin of the leaf, in the usual manner, would appear to run across the anther, or at right angles to the connective, and should the opening in the one lobe join on to that in the other, might simulate the appearance of a

lled anther. When the opening runs across the
ı this manner, the dehiscence is said to be *trans*-
g. 184). Ex. Lady's Mantle, &c.

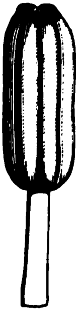
FIG. 184.



Transverse Dehiscence.

ROUS DEHISCENCE.—When the anther bursts by
enings usually situated near its apex, the de-
is said to be *porous*. These pores are produced
uture opening only a small way instead of along

FIG. 185.



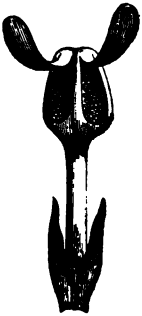
Porous Dehiscence.

ire face or side of the anther (Fig. 185). Ex.
n, &c.

LVULAR DEHISCENCE.—When a portion of the wall
nther gives way at every point save one, which

remains as a sort of hinge attaching this lid to the : the anther, and so as to leave an opening in its sic dehiscence is termed VALVULAR (Fig. 186). Ex. berry, &c.

FIG. 186.

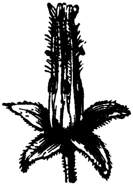


Valvular Dehiscence.

The stamens collectively present some peculia which, as affording valuable means for distingu genera, are important to the student. These peculi will be best considered under the heads of—1st. N 2nd. *Position.* 3rd. *Relative Length.* 4th. *Union.*

1. NUMBER OF STAMENS.—Linnæus, in arrangir

FIG. 187.



Diplostemenous Stamens.

vegetable kingdom according to his artificial s seized on the important characters yielded by the st *as to number*, &c., for distinguishing his classes, a *terms* are still retained.

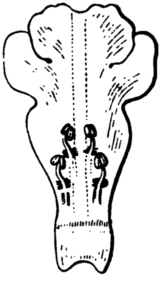
When the stamens are equal, in point of number, to the sepals and petals, the flower is said to be ISOSTEMENOUS; but if their number be not the same as that of the sepals and petals or a multiple of it, the flower is said to be ANISOSTEMENOUS. Sometimes the number of stamens is equal to the sum of the two outer whorls, when the flower becomes DIPLOSTEMENOUS, but this term is sometimes used otherwise.

A flower which has one stamen is MONANDROUS, one with two DIANDROUS, &c., but fuller details as to these points will be given when considering the Linnæan classification.

II. POSITION OF STAMENS.—As to position, or insertion, stamens may be *Hypogynous*, *Perigynous*, or *Epigynous*, the meaning of which terms has been already explained. When inserted on the inner faces of the petals, they are said to be EPIPETALOUS (Fig. 188). According to the law of alternation, the stamens, if they constitute but a single whorl, or the outer of these if there be more than one, should alternate with the petals. Occasionally, instead of being *alternate* with the petals, they are *opposite* to them, which may be accounted for by the doctrine of chorisis, as already explained; or, what is more likely, by the suppression of an intermediate whorl.

III. RELATIVE LENGTH.—Instead of being all of an equal length, it *occasionally* happens that some of the *stamens are longer than* others. Thus, in the Labiatæ,

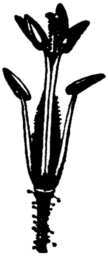
FIG. 188.



Epipetalous and Didynamous Stamens.

there are two long and two short stamens, on
count their stamens are said to be Didynamo
Cruciferæ, again, there are four long and two sh
the term Tetradynamous is applied to them

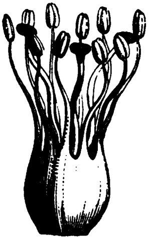
Fig. 189.



Tetradynamous Stamens.

When all the stamens are shorter than the
corolla, they are said to be *Included*, as in Cincl
they are longer, and project beyond it, they
be *Exserted*, or *Protruding*, as in the Plantain
IV. Union.—As to union, stamens are eith

Fig. 190.

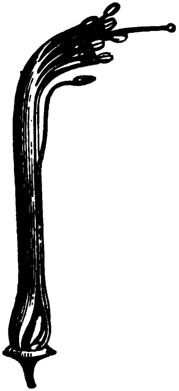


Monadelphous Stamens (Erythroxylon Coca)

tinct, and hypogynous, as in the Ranunculus,
by adhesion, *Perigynous*, *Epigynous*, &c. The
cohere into a single bundle by their filaments
phous, *as* in the Mallow), into two (Diadel

e Pea), into three (TRIADELPHOUS, as in the Hypericum), to four (TETRADELPHOUS), or into several (POLYADEL-

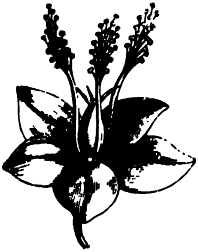
FIG. 191.



Diadelphous Stamens (Bean).

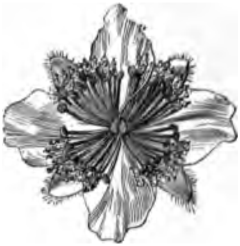
PHOUS). Where, instead of cohering by their filaments, stamens are united by their anthers only, they are said to be SYNGENESIOUS (Fig. 194), as in the Compositæ.

FIG. 192.



Triadelphous *Stamens* *(Hypericum).*

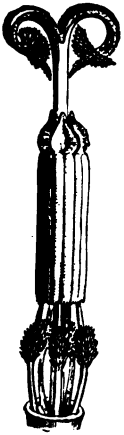
FIG. 193.



Tetradelphous Stamens (Sparmannia).

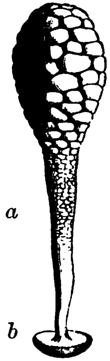
When they adhere to the pistil, they become G DROUS, as in Orchidaceæ (Fig. 195).

FIG. 194.



Synantherous or Syngenesious Stamens.

FIG. 195.



Pollinia (Orchis macul *a*, Caudicle; *b*, Retina

POLLEN.—The origin, structure, and properties of] will be discussed in another connexion; suffice it t here, that pollen is usually made up of distinct grain in the Orchidaceæ and Asclepidaceæ the different { cohere, constituting what are called POLLINIA, or] masses. Occasionally, these masses are furnished v stalk-like process, called a CAUDICLE, which ends glandular enlargement for attaching it to foreign b called the RETINACULUM.

CHAPTER X.

MORPHOLOGY.

THE PISTIL.

OCCUPYING the organic apex of the flowering axis, and within the stamens, though sometimes separated from them by the organ described as a Disk, stand the Pistils.

No folding is necessary to account for the changes the leaf undergoes in its transformation into petals, sepals, and stamens; though some botanists look upon the anther as formed by the folded blade of a regular leaf. In describing the pistil, in accordance with the leaf type, folding will be found necessary to account for the altered appearance assumed by the leaf.

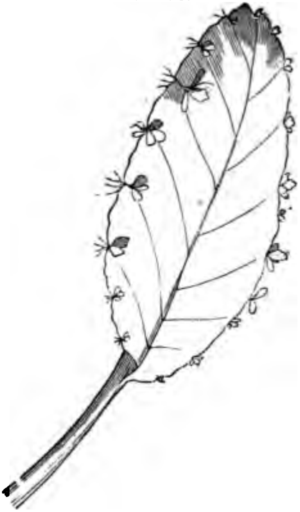
Each individual constituent of the Pistilline whorl is termed a CARPEL, and may be looked upon as a *conduplicate leaf with the edges turned inwards.* The lower part of the carpel consists of a cavity, containing modified buds or OVULES, produced on the inturned edges of this carpellary leaf. On this account the cavity is called the OVARY. The inturned edges of the leaf constitute what is called the PLACENTA. The type of the ovules must be looked for in the buds produced on the leaf edges of such plants as the Bryophyllum (Fig. 196) and Malaxis.

Surmounting the ovary, in most cases, there is a long slender organ, termed the STYLE; this has by some been looked upon as the prolonged midrib of the carpellary leaf, but it differs from a midrib in section, and still more decidedly in being hollow. On this account the style must rather be looked upon as a contracted portion of the ovary. Terminating the style is an organ which differs from every other part of the plant in possessing no external covering (epidermis). It is the enlarged glandular extremity of the style, and is called the STIGMA. When the style is absent, as in the Poppy, the Stigma is said to be SESSILE.

Another theory as to the morphology of the Pistil, was propounded by the renowned Schleiden. He looked upon the placenta *as the direct prolongation of the primary or secondary axis, the* ovules, as modified buds, originating

from this axis, and the carpellary leaves as bracts pe
modified for the protection of these buds. This
well adapted to account for the appearances obse
such plants as the Primrose, where, in a *compound* c
i.e., in one consisting of more than a single pis
placenta is altogether unconnected with the wal
occupies the centre of the cavity. On the other l
does not so well apply to cases where the place

FIG. 196.



Leaf of Bryophyllum producing buds at its edges.

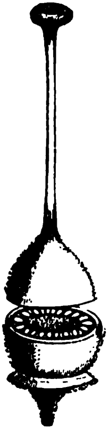
heres to the wall of the ovary, as in what, on tl
theory, is the typical case.

In opening to allow the escape of the ripe ovu
ovary usually gives way either at the placenta o
midrib. Hence the line of the former is termed t
TRAL, that of the latter the DORSAL suture.

NUMBER.—It rarely happens that the number o
exactly corresponds with the number of parts in

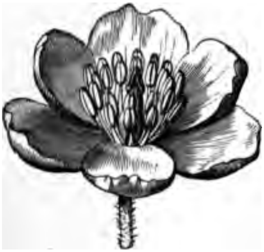
the outer whorls; but, according to the definition, this does not interfere with the *symmetry* of the flower. In the Leguminosæ, where the number five prevails in the outer whorls (*quinary symmetry*) the carpels are reduced to one. In the Ranunculaceæ the carpels are often very

Fig. 197.



Transverse section of Pistil of Primrose—unilocular ovary with free central placenta.

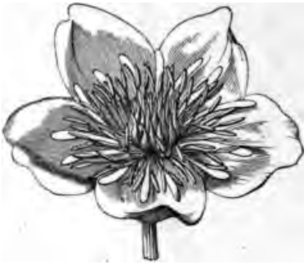
Fig. 198.



Flower with solitary Pistil.

numerous, and are, therefore, said to be INDEFINITE. The number of pistils in the flower was seized upon by Linnæus as furnishing characters for the orders in his artificial system. He used such terms as *Monogynous* when there is but one pistil, *Digynous* when two, and so on, as will be afterwards explained.

FIG. 199.



Flower with indefinite Pistils.

UNION.—When there is only one pistil in a flower, or where all the pistils are distinct, they are said to be SIMPLE (Fig. 198). Where, on the other hand, they cohere with each other, the term COMPOUND is applied to them. Other terms are employed almost synonymously with these: thus, when free, they are said to be APOCARPOUS, when united, SYNCARPOUS.

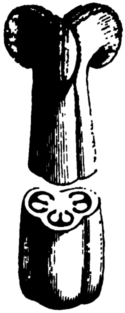
The degree of union in *Syncarpous* pistils is exceedingly varied. Sometimes they are closely united in the ovary, style, and stigma, in which case the number of component carpels can only be made out by counting the depressions which usually exist where one carpel joins another, or the prominences corresponding with the midribs. Even this fails in some instances, where the number can only be made out by cutting across the ovary, and counting the number of placentæ.

In the Stonecrops the pistils are coherent, but *not entirely* so, being free at the summit. In the Pink, the *style alone* is free; in the Geranium, the stigmas only are *separate*; while the Primrose has every part coherent. *On the* other hand, the style may be bifid, as in Euphor-

The syncarpous pistil being composed of a number iple pistils grown together, the same parts must be l for in both the simple and compound varieties.

dorsal suture is seen in both, but owing to position ntral suture cannot be so easily made out in the rpous pistil, as it, along with the placenta, will y the centre of the cylinder formed by the coherent s. At the points where the carpels grow together, must be a certain degree of flattening to allow approximation, so that between the cells of adjacent s there will be a double partition formed by the ned portions of the adjacent walls of the adjacent

FIG. 200.

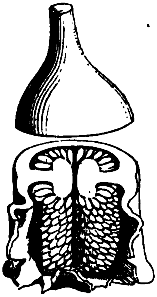


Trilocular ovary with central placenta.

ls. These partitions are called DISSEPIMENTS, and the es LOCULI or LOCULAMENTS. Such a compound ovary l to be MULTILOCULAR, and its placenta is said to be AL.

some cases the double partitions do not reach the e of the ovary, but project only a small way from all, as the placenta does in a simple pistil. In an ovary there are no dissepiments, so that it is to be UNILOCULAR, and the placentæ are said to be *al.* Though closely resembling the placenta in a e pistil, the same organ in such a pistil has a nt constitution, not being formed of the inturned *of a single carpellary* leaf, as in the simple and multilocular ovaries, but by the adjacent inturned e of two coherent carpellary leaves. In this variet

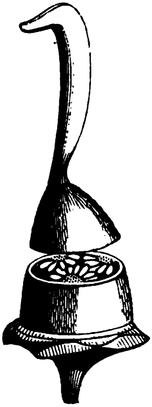
FIG. 201.



Unilocular ovary with two parietal placentæ.

ovary the carpellary leaves must be looked upo arranged in the manner described under the hea

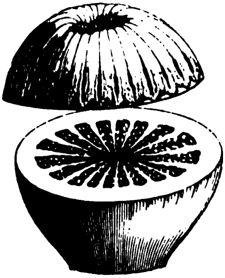
FIG. 202.



Unilocular ovary with three parietal placentæ.

, as *Induplicate.* Between this kind of ovary
former there is every intermediate variety.
tain cases a different condition obtains; here, as
e ovary is unilocular, but it is supposed to be so
struction of the dissepiments of a multilocular
aving the placenta in the centre of the cavity
unconnected with the sides of it at any part.
ovary is said to be UNILOCULAR, with a FREE
PLACENTA (Fig. 197).
sepiments not formed by the inturned carpellary
re said to be FALSE or SPURIOUS. Accordingly,
rtitions are horizontal instead of vertical, they
a general rule, be false, except in such cases as

FIG. 203.

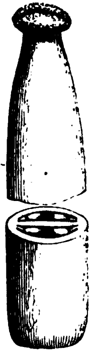


f Poppy, with numerous placentæ covered with ovules.

granate, where a number of carpels are placed
d instead of side by side. It also results from
in a simple ovary there can be no true dissepi-
d that in a compound ovary their number should
to the number of carpels. As examples of
dissepiments there may be cited the transverse
s, called PHRAGMATA, seen in the Cassia fistula, and
al one, which in this case is called a REPLUM (Fig.
n in the fruit of the Cruciferæ (Mustard family).
VARY.—When composed of only one carpel, the
said to be SIMPLE; when of more than one,
D. Contrary to the general leaf type, the ovary
without a stalk for its support. When such

an organ is present, it is termed a GYNOPHOI ovary is said to be STIPITATE (Fig. 150). The pos ovary with regard to the calyx is indicated bj SUPERIOR, when the calyx is quite distinct inserted below the ovary, and HALF SUPERIC INFERIOR when the adhesion extends half w ovary. The INFERIOR condition of the ovary, completely covered by the calyx, may be simul the Rose, by the development of the recept cavity, in which the carpels are contained.

FIG. 204.



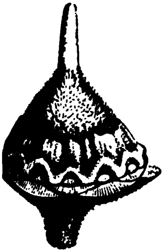
Bicarpellary ovary of Crucifer with false dissepi

PLACENTA.—As already explained, the I usually looked upon as the *inturned and conj of the carpellary leaf*, as is evident enough in where the pistil is simple. Instead of being co single spot, the placenta sometimes extend whole inner surface of the carpellary leaf, Water Lily; but this is unusual. Schleiden, and others, however, maintain that as the deve buds on the edges of ordinary leaves is an al such a condition must not be taken as the typ duction in all cases. They account for the pr *ovules* in the same way as ordinary bud *development* from the axis, which they say is the placenta, and in the axils of bracts, which have umed the shape of carpellary leaves.

This theory applies very well to cases of *free central* or ile, but not so well to those of *parietal* placentation. the Primrose there is an axile placenta, which is never nnected with the walls of the ovary; such a condition best explained on Schleiden's theory. In many Caryo-yllaceous plants, as the Lychnis, there is also a free ntral placenta, but at an early period the ovaries of iese possess true dissepiments connecting the placenta ith the walls of the ovary, and showing its parietal rigin. Ordinary cases of parietal placentation are wkwardly accounted for on Schleiden's theory, by sup-osing that the axis (secondary axis) divides into a umber of branches, which pass along and adhere to the lges of the carpellary leaves or bracts, and bear ovules t certain intervals.

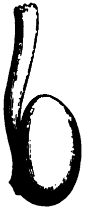
STYLE.—The *style* usually rises from the top of the vary, but in some cases instead of doing so, it appears originate from the side or even the base of the ovary. hen rising from the top, as in the Primrose, the style said to be APICAL OR APICILAR; when from the side, as the Strawberry, LATERAL; and when from the base, as the Lady's Mantle (Alchemilla), it is said to be SILAR. When several ovaries with lateral or basilar yles are so united, as in the Labiatæ, that the com-und style appears to be such a prolongation of the ceptacle *as is seen in the* Geranium, the styles are said

FIG. 205.



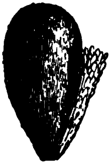
ical or terminal style.

FIG. 206.



Lateral style.

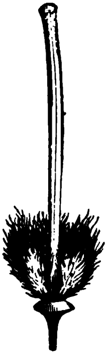
FIG. 207.



Basilar style.

to be GYNOBASIC. Occasionally, as in the Iris, so far returns to the leaf type as to become PE its upper part.

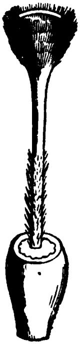
Fig. 208.



Gynobasic style (Gaudichaudia).

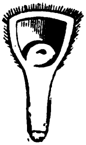
STIGMA.—Terminating the style, which, ho not always present, is that portion of it called th

Fig. 209.



Capitate terminal stigma.

Fig. 210.



Section of the sam

Some botanists look upon this organ as being the continuation of the placenta, but so modified as to produce no ovules. When the style is absent, the stigma is said to be SESSILE. It may be SIMPLE or COMPOUND, and in the latter case DISTINCT, when the stigmas of the different carpels do not unite, but CONFLUENT when they do, as in the Poppy. Stigmas may be either TERMINAL when at the extremity of the style, or LATERAL when the two adjacent sides of that portion of the carpellary leaf which forms the style do not unite at their upper part. When the stigma forms a distinct swelling or head at the top of the style, it is said to be CAPITATE. In the Grasses the stigmas are FEATHERY or PENICILLATE, in the Compositæ they are LOBED, in the Poppy they are RADIATE, in the Leguminosæ they are LATERAL, and in the Iridaceæ they are PETALOID.

OFFICINAL.

Crocus—the stigma and part of the style of Crocus Sativa (Saffron) …………	A colouring agent, &c.

CHAPTER XI.

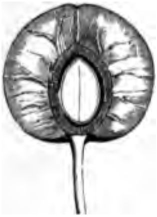
THE FRUIT.

The next organ that should be described is the ovule, but as it will be more conveniently described along with the seed, and as the fruit is mostly composed of the matured ovary, the latter will be described before the former. As a consequence of the fertilization of the ovules by the pollen, a series of changes is set up, ending in the conversion of the ovule into the seed, which, along with its covering, constitutes the fruit. As a rule, the outer organs of the flower fall off immediately after fecundation; sometimes, however, the calyx remains, and forms a part of the fruit. The style and stigma generally disappear also, but in some instances the style persists, and forms what is called the BEAK or TAIL of the fruit. If the calyx persist, it may either be in a loose condition, as in the Labiatæ, where it is inferior, or being superior, may constitute one of the coverings of the fruit, as in the *apple*, &c. Many fruits differ widely in character from the ovaries of which they are composed, and these changes may be brought about in various ways. First they may be effected by *the suppression of loculi and ovules*, as in the Birch, Oak, and Hazel, where the dissepiments and loculi are obliterated by pressure; secondly, the fruit may be altered by *the development of false dissepiments*, as in the Datura, where an upright partition is developed, converting the two-celled ovary into a four-celled fruit. In the third place, membranous ovaries may become *succulent fruits*, by the formation of pulp from the placenta, &c., as in the Orange, and so on.

COVERING.—The case or covering of the fruit, however constituted, is termed the PERICARP. In consistence it varies greatly, but is generally said to be either DRY or SUCCULENT. In the Pea the pericarp is *dry* and *membranous;* in the Cardamomum it is *leathery;* in the Hazel it is *woody;* while in the Gooseberry, Plum, &c., it is *succulent*. When the pericarp is dry and membranous, *no distinct* layers can be made out in it; but in some of *the* succulent forms, three distinct layers can be re-

Thus, in the Cherry (Fig. 211) there is first of ıkin, corresponding with the epidermis on the ·face of the leaf, and termed the EPICARP. Next .e fleshy part, corresponding with the fleshy part ıchyma of the leaf, and called the MESOCARP. ;his, and homologous with the epidermis of the ırface of the leaf, is the stone or PUTAMEN, also ,he ENDOCARP, which encloses the seed. In the › albuminous seed itself constitutes the stone.

FIG. 211.



Section of a Drupe (Cherry).

;ENCE.—As the grand end of the fruit is the pro- f the seed for the propagation of the species, all ges which take place in it have a view to the ulti- ıefit of the seed. Accordingly some fruits, more y succulent ones, and those possessing a very hard , fall from the plant without allowing the seed to Having thus fallen, their decomposition at once a soil favourable to future development of the ile it opens up a route for the passage of the Such fruits are said to be INDEHISCENT. When, ontrary, the fruit breaks or opens up and allows ıed seeds to escape, it is said to be DEHISCENT. ehisce in one or other of three modes:—

hey may open longitudinally along the lines of tural sutures, and the parts fall away in the form s. This mode is termed VALVULAR.

Instead of opening longitudinally, a transverse y separate the upper from the lower part of the e former falling off like a lid, and leaving the ıcovered. This kind of dehiscence is termed the *ISSILE, or TRANSVERSE.*

3rd. In some instances the fruit opens by small pores only, when the dehiscence is said to be POROUS.

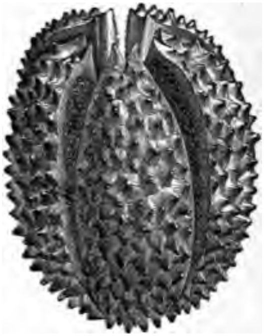
1. VALVULAR DEHISCENCE.—When the sutures of a fruit open, they may do so the whole way down, or only partially, as in many Caryophyllaceous plants (Pink, &c.), where they only open far enough to form little projections like teeth. In those cases where the sutures open the whole way down, it is evident there must be some difference between the fruits which have septa and those which have not; in other words, between simple and compound fruits.

SUTURAL DEHISCENCE.—When the fruit is composed of single carpels, these may open either by both dorsal and ventral sutures, as in the Pea; by the dorsal alone, as in the Magnolia; or by the ventral suture alone, as in the Hellebore. All these, however, seeing that they dehisce along their sutures, furnish examples of SUTURAL Dehiscence.

When, again, dissepiments exist, the fruit may burst in one or other of three ways:—

A. SEPTICIDAL DEHISCENCE.—When the carpels which constitute the Syncarpous pistil separate from each other, so as to divide the septa into their component parts, the *dehiscence* is said to be SEPTICIDAL (Fig. 212).

FIG. 212.

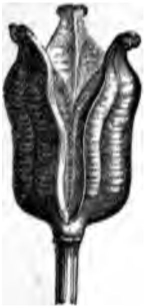


Septicidal Dehiscence.

B. LOCULICIDAL DEHISCENCE.—When, again, each carpel

its dorsal suture, or that part which corresponds
cavity or loculus in its interior, while the ad-
rts of the different carpels remain coherent, so
septa are entire, the dehiscence is said to be
DAL (Fig. 213).

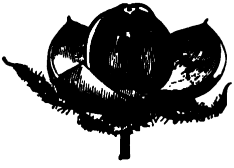
FIG. 213.



Loculicidal Dehiscence.

PTIFRAGAL DEHISCENCE.—When in addition to this
of the loculus, at the dorsal suture of the carpel,
ssepiment is broken across transversely, leaving
enta standing up in the centre of the ovary, and
separated from its connexion with the walls, the

FIG. 214.



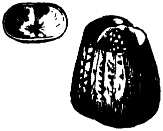
Septifragal Dehiscence.

nce is said to be SEPTIFRAGAL (Fig. 214), and the
ng placenta is called the COLUMELLA.
e are the typical modes; but under each head there
ious modifications. Thus, in the Septicidal form,
entæ of a compound ovary may be left as a colu-

mella, as in the Rhododendron; or the separated carpels may dehisce each in the manner of simple pistils, as in Colchicum. In the *Loculicidal* form of dehiscence the projecting septa may either carry the placentæ, as in the Iris; or leave them behind, as in the Heath. In the *Septifragal* variety the carpels may split at their ventral, as well as at their dorsal sutures, as in Datura.

2. Circumcissile Dehiscence takes place in membranous fruits such as Hyoscyamus (Fig. 215), or in woody fruits like Lecythis. As to the cause of this transverse division, some botanists look upon the carpellary leaves as being in such cases compound, like those of the Orange, and the blade as separating from its stalk at the terminal joint. Others think that the lower part of the ovary is formed of the developed receptacle, the upper and separating part, of the carpellary leaves.

Fig. 215.



Circumcissile Dehiscence—Pyxidium of Hyoscyamus with operculum removed.

3. Porous Dehiscence, such as that seen in the Poppy, seems to be caused by the rupturing of thin spots in the walls of the ovary, from the distension or contraction of the neighbouring parts.

Classification of Fruits.

From the great variety of fruits known, some classification is absolutely necessary to their study, but up to the time of Professor Lindley little had been done in this direction. Even now the arrangements usually adopted are anything but satisfactory, although they nearly all take Lindley's classification as their basis.

Fruits may, however, be arranged in two great divisions—the one containing all fruits produced by a *single flower,* the other those comprising the products of *more than one* flower. The former may be denominated simple, nd the latter MULTIPLE fruits. Of simple fruits, again, here are two grand subdivisions, according to the nature f the pistil, whether APOCARPOUS or SYNCARPOUS. These may in their turn be each subdivided into two other groups, the *Apocarpous*, into such as are composed of one carpel only, which might be denominated SIMPLE APOCARPOUS, and those composed of a number of distinct carpels, which might be called COMPOUND APOCARPOUS. When, again, the fruit is *syncarpous*, it may be either INFERIOR or SUPERIOR, according as the calyx forms one of the coverings of the fruit or not.

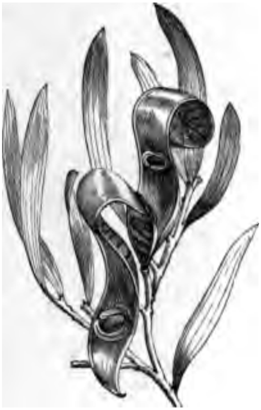
A. SIMPLE FRUITS.

I. SIMPLE APOCARPOUS FRUITS.

These are two in number—the LEGUME and the LOMENTUM.

1. The LEGUME is a simple apocarpous fruit, dehiscing by both dorsal and ventral sutures (Fig. 216). Ex. the Pea, &c. Sometimes it is twisted, as in Medicago; and it may be divided by transverse false dissepiments or phragmata, as in *Cassia fistula*, &c.

FIG. 216.



Legume dehiscing.

2. The LOMENTUM differs from the Legume, in l
moniliform constrictions and false dissepiments at
vals. When ripe, it usually breaks across thes
stricted spots, but the individual portions do not
dehisce. Ex. Acacia.

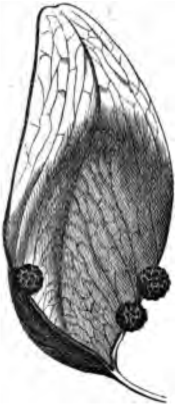
B. SIMPLE APOCARPOUS FRUITS SOMETIMES DEH
THE UTRICLE.—This is a one-celled, one- or many-
fruit, having a loose membranous pericarp, som
dehiscing transversely. Ex. Chenopodium.

C. SIMPLE APOCARPOUS FRUITS NEVER DEH
DRUPE.—The DRUPE OR STONE FRUIT may be defined
apocarpous, indehiscent, one-celled, one- or two-
fruit, consisting of a fleshy *sarcocarp* and a stony *en*
or *putamen*. Ex. Cherry and Peach.

II. COMPOUND APOCARPOUS FRUITS.

A. DEHISCENT. 1. FOLLICLE.—The Follicle differ
the Legume in dehiscing by a single suture inst

FIG. 217.

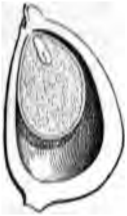


Follicle of Sterculia dehiscing.

by both, and in being produced in some num
each flower, but in no other respect (Fig. 217
Hellebore, Pæony, &c.

DEHISCENT. 1. **ACHENE.**—The Achene is a dry,
ous, indehiscent fruit, having but one cell and one
t closely resembles a seed in outward appearance;
however, be distinguished from a seed by being
y the remains of the *style* (Fig. 218). Ex. Ranun-
o.

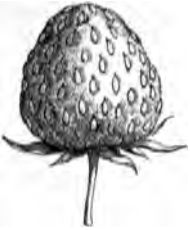
FIG. 218.



Section of an Achene.

ÆRIO.—The fruit known as the Etærio is of a
at varied nature, but there are two chief kinds
uishable. Thus—
The fruit of the Strawberry is an Etærio. It con-
f an enlarged succulent receptacle, supporting a

FIG. 219.

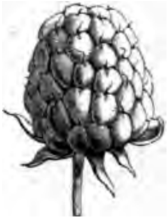


Strawberry.

r of achenes. In this case the edible part is the
cle, the small seed-like bodies on its surface being
s (Fig. 219). In the Ranunculus there is the same
f *structure, but the* receptacle is not succulent.

2nd. The Raspberry is also called an Etæri
edible part is composed, not of the receptacle,
Strawberry, but of a number of drupes, suppor
receptacle, fleshy but not succulent (Fig. 220).

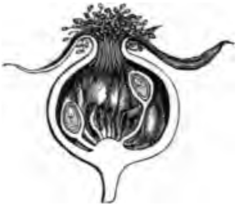
Fig. 220.



Raspberry.

The Cynarrhodum or Rose-hip.—This fruit
an inverted Etærio; that is, the succulent rece
stead of being elevated for the support of the a
hollowed out into a cavity for their reception (Fi

Fig. 221.



Section of Cynarrhodum or Rose-hip.

I. Syncarpous Superior Fruits.

A. Indehiscent.

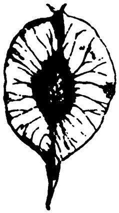
a. Pericarp Dry.

1. The Caryopsis closely resembles the Ach
which it differs in being composed of 2, rarely
instead of one only, and in having the perica

attached instead of being loose. It occurs in Grasses, as Oats, &c.

2. The SAMARA or KEY consists of two or more coherent achenes with winged margins, and is seen in the Ash, Elm, &c. (Fig. 222).

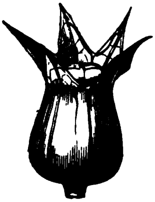
FIG. 222.



Samara or Key (Ash).

3. CARCERULUS.—When, as in the Mallow, the axis is prolonged into a kind of carpophore, the individual carpels, or achenes, situated round its base, often separate from the axis at that point, but remain connected with it at its upper part. The separate carpels are termed COCCI, and the whole collection of them a CARCERULUS. When the COCCI are dehiscent, the collection is sometimes termed a REGMA.

FIG. 223.



Pyxidium (Hyoscyamus).

4. The TRYMA is merely a compound drupe. Ex. Walnut. Sometimes the *outer coat* is fibrous, as in the Cocoanut.

β. Pericarp Succulent.

1. Nuculanium or Uva.—This kind of fruit an outer skin, or pericarp, containing a numbe surrounded by a pulp, as in the Grape. It di the Gooseberry only in being *superior* instead o

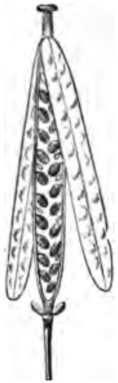
2. Hesperidium or Orange.—This does very materially from the Grape, save in the p of the septa, from which the pulp arises, and rind.

B. Dehiscent.

1. The Capsule is a *superior* one- or more-cell seeded fruit, dry, and dehiscing by valves, as cum, or by pores, as in the Poppy; when i transversely, as in Hyoscyamus, it is called a (Fig. 223).

2. The Siliqua differs from the former in co

Fig. 224.



Siliqua.

only two carpels, with parietal placentæ. It septum, termed a replum, stretching acros these, and dehisces by valves (Fig. 224). Whe broad, instead of long and narrow, it is termed *This* variety of fruit is found throughout the *family*.

II. INFERIOR SYNCARPOUS FRUITS.

A. INDEHISCENT. *a.* DRY.

1. GLANS or NUT.—This is a dry, *inferior*, one-celled, single-seeded fruit, the other cells being obliterated by pressure. Usually it is situated in a whorl of bracts forming a cupule. Ex. Acorn.

2. The CYPSELA is an *inferior* achene, having the calyx attached in the form of a PAPPUS, seen in all Compositæ.

3. The CREMOCARP is an *inferior* carcerulus, consisting of two carpels, known as *Mericarps.* It is seen in the Umbelliferæ. Each mericarp is an inferior achene.

β. SUCCULENT.

The BACCA or Berry is an *inferior* nuculanium. Ex. Gooseberry.

2. The POMUM or Apple bears the same relation to the Bacca that the Orange (Hesperidium) does to the Grape (Nuculanium), except that in it the endocarp forms a core more or less bony. Ex. Apple, Quince, Hawthorn, &c.

3. The PEPO differs from the Pomum in being one-celled and pulpy, and in having the rind thickened or hardened. Ex. Gourd and Cucumber.

4. The BALAUSTA or POMEGRANATE differs from all other fruits in having its carpels arranged in two stories, instead of side by side. In outward appearance it resembles the Orange, but is *inferior.*

B. DEHISCENT.

The only fruit belonging to this group is the DIPLOTEGIA, seen in the Campanula; it differs from the Capsule in nothing save its *inferior* position.

B. MULTIPLE FRUITS.

Fruits formed by more than one flower are called ANTHOCARPOUS, or MULTIPLE. Of these, the most important are—

1. THE CONE.—This is an elongated multiple fruit, consisting of a number of hardened scales, each of which bears one or more seeds in its axil. As to the nature of these scales, some botanists believe that they are bracts, as described under that head; others, that they are open carpels. Cones are the only fruit produced by Pines and Cycads, which, on account of having their seeds naked, are called GYMNOSPERMS.

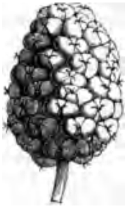
2. *The GALBULUS differs* from the Cone in shape, being

more rounded, and in having the extremities of i ponent scales flattened like the head of a nai Cypress. In the Juniper the scales are fleshy. Yew the fruit is single, and enclosed in a cup.

3. STROBILUS.—This differs from the Cone in its scales membranous and its seeds enclosed in but in no other respect. Ex. the Hop.

4. SOROSIS is the ripened product of a number of so closely coherent as to appear but a single one (Fi Ex. Mulberry, Breadfruit, Pineapple.

FIG. 225.



Sorosis of the Mulberry.

5. The SYCONUS is a ripened *cœnanthium.* E Dorstenia, &c.

OFFICINAL FRUITS.

Cocculus—fruit of Anamirta or Menispermum Cocculus	Irritant.
Papaver—dried capsules (nearly ripe) of Papaver somniferum	Sedative.
Aurantii Cortex—rind of Citrus Bigaradia (Bitter Orange)	Aromatic and Stor
Limonis Cortex Limonis Oleum Limonis Succus } got from the fruit of Citrus Limonum ...	Stimulant and Carı Antiscorbutic.
Bela—half ripe fruit (dried) of Aegle Marmalos	Astringent.
Uva—ripe fruit of Vitis vinifera (Vine)	Sweetening agent.
Rutæ Oleum—distilled from the fresh leaves and unripe fruit of Ruta graveolens................................	Stimulant and modic.
Cassia—pulp of the fruit of Cassia fistula	Laxative.
Tamarindus—pulp of the fruit of Tamarindus Indica	Laxative.
Prunum—dried fruit of Prunus domes*tica*	Laxative.

Rosa canina—hips of R. canina (Dog Rose)	Sweetening and Astringent.
Pimenta Pimentæ Oleum unripe fruit of Eugenia Pimenta	Stimulant.
Colocynthis—dried decorticated fruit of Citrullus Colocynthis	Purgative.
Elaterium—deposit from the juice of the fruit of Ecbalium Officinarum	Hydragogue Purgative.
Anisi Oleum—oil distilled from the fruit of Pimpinella Anisum and Illicium Anisatum	Stimulant and Carminative.
Fœniculum—fruit of Fœniculum dulce (Fennel)	Stimulant and Carminative.
Coriandrum Coriandri Oleum dried fruit of Coriandrum sativum	Stimulant and Carminative.
Conii Fructus—fruit (ripe) of Conium maculatum (Hemlock) act. prin. Conia	Sedative.
Carui Carui Oleum dried fruit of Carum carui	Stimulant and Carminative.
Anethum Anethi Oleum fruit of Anethum graveolens (Dill)	Stimulant and Carminative.
Olivæ Oleum Sapo Duris Sapo Mollis Glycerinum all got from the fruit of Olea Europeæ (Olive)	Demulcent.
Piper—unripe berries of Piper nigrum	Stimulant.
Cubeba Cubebæ Oleum unripe fruit (dried) of Cubeba officinalis	Stimulant, &c.
Capsicum—fruit of Capsicum fastigiatum	Stimulant.
Ficus—ripe fruit of Ficus carica (Fig)	Laxative.
Mori Succus—juice of the fruit of Morus nigra	Refrigerant.
Lupulus—dried strobile of Humulus Lupulus (the Hop)	Sedative and Tonic.
Juniperi Oleum—distilled from fruit of Juniperus communis	Stimulant and Diuretic.
Sabadilla—dried fruit of Asagræa officinalis	Irritant.

FRUITS FORMERLY OFFICINAL.

Rhamni Succus—juice of the fruit of Rhamnus catharticus	Purgative.
Mucuna—hairs of the fruit of Mucuna pruriens	Anthelmintic.
Cyminum—fruit of Cuminum Cyminum	Stimulant and Carminative.
Laurus—fruit of Laurus nobilis (Sweet Bay)	Slightly Stimulant.
Piper longum—fruit (unripe) of Piper longum	Stimulant.

CHAPTER XII.

MORPHOLOGY.

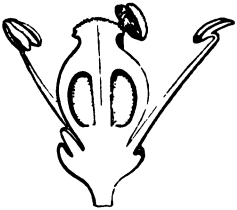
THE OVULE.

THE only other organ which has to be descri modified bud which, originating on the inturn carpellary leaf, is termed an OVULE. After and the formation of an embryo in its interior called a SEED.

When only one ovule is seen in each ovar Ranunculus, it is said to be *solitary*. Wh more numerous, but still easily counted, t *definite*, as in the Pea, &c. Whereas, wh very numerous, as in the Poppy, they are *indefinite*.

To denote the position of the ovule in various terms are employed. If it appear

FIG. 226.

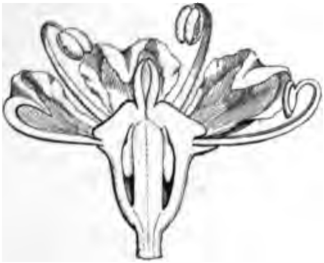


Erect Ovules (Vine).

the bottom of the ovary, and to stand upright, it ERECT (Fig. 226). When it hangs from the su ovary it is said to be PENDULOUS (Fig. 227). If rise from the side near the bottom, and to be wards, it is said to be ASCENDING; and if n and to hang downward, SUSPENDED. Shoul grow straight outward, it is said to be HO *PELTATE*. The term *Pendulous* is often used fo *and vice versâ*, so that there is considerable plication; a description of the state of matters, e, rather than these technical terms, should be d in describing an ovule.

other buds, the ovule first appears as a small protuberance from the placenta. This goes on ıg till the original projection, termed the NUCLEUS, ated from the placenta by a slender cord-like lled from its analogy to the navel-string in the the UMBILICAL CORD, the FUNICULUS, or PODO- When this is absent, the ovule is said to be Coincident with the growth of this body (the , two coverings for the ovule are gradually d from its base, where the funiculus joins it. nt of junction is called the UMBILICUS or HILUM.

FIG. 227.



Pendulous Ovules (Heracleum barbatum).

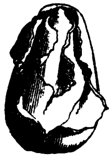
ner of these two coverings appears first. In ses, as in the Mistletoe, the nucleus is *naked;* thers, as the Walnut, it has but *one* coat, called GUMENTUM SIMPLEX.

ner coat, or that which appears first, is called the ENTUM INTERNUM; the outer, the INTEGUMENTUM M. Mirbel imagined that the outer coat was eloped, and therefore called it the PRIMINE, and rnal, as coming after it, the SECUNDINE; but terms have been also employed with an opposite tion, it is better to avoid their use altogether. of the coats completely covers the ovule, so that space at the *apex is* left unprotected to allow of *ication of the* pollen tube. This small opening is called the MICROPYLE or FORAMEN, the opening in th outer coat being called the EXOSTOME, and that in th inner coat the ENDOSTOME. This indicates the organi apex of the ovule.

Coincidentally with these changes on the outsid of the nucleus or ovule proper, certain others tak place internally, fitting it for the production of an embryo. The chief of these changes is the formation of cavity by the development of certain of its cells in peculiar manner. This cavity is termed the EMBRY SAC.

Although the funiculus appears to join the ovule a the hilum, it may not join the nucleus there, and th spot where this union takes place is called the CHALAZ. As the *micropyle* indicates the organic *apex* of the ovul so the *chalaza* indicates its true *base*. When the hilu

FIG. 228.



Orthotropous Ovule and its coverings—ruptured to show the nucleus projecting at the micropyle.

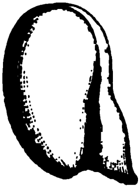
and the chalaza correspond, that is to say, when the bas of the ovule is directed toward the placenta and its ape away from it, the ovule is said to be ORTHOTROPO (Fig. 228).

Sometimes, however, the funiculus becomes attached t the covering of the ovule, and by its further growt elevates the base of the ovule so as to have the chala directed away from, and the micropyle turned towar the placenta. Such a condition is termed ANATROPO (Fig. 229). In this case the hilum and micropyle w be close together, and the funiculus will form a cor like projection on the surface of the ovule, called t *RAPHE.*

In certain cases the ovule becomes bent on itself in t shape of a U, bringing the chalaza and hilum, which be orrespond, almost in contact with the micropyle. Such n ovule is said to be CAMPYLOTROPOUS (Fig. 230). It is een in the Cruciferæ.

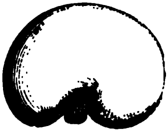
A fourth condition, more rarely met with, consists of n elongation of the funiculus, pushing up the chalaza nd down the micropyle, so as to make the long axis of

FIG. 229.



natropous Ovule, showing micropyle and hilum adjacent.

FIG. 230.



Campylotropous Ovule.

he ovule horizontal instead of vertical: this is termed MPHITROPOUS, HETEROTROPOUS, or HEMIANATROPOUS.

These terms must not be confounded with the terms *rect*, &c., already explained, which refer to the position f the ovule in the carpel, while the terms just explained escribe the relations of the parts in the ovule to each ther.

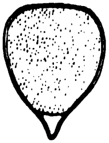
THE SEED.

IN describing the seed, exactly the same term
ployed as in the case of the ovule to indicate its
the ovary, &c. Like the ovule, also, it consists of
and its coverings, but these coverings differ in c
portant respects from the corresponding par
ovule. The funiculus and hilum have the some
in both, and the terms *orthotropous*, *anatropou*
applied with a like signification to both.

Though the coverings of the seed be two in
these do not correspond with the two coverin
ovule, nor have they the same names. The ou
ing of the seed is termed the TESTA, EXOPLE
SPERM, or SPERMODERM. The inner is called th
or ENDOPLEURA. The *testa* varies greatly in co
being sometimes membranous, sometimes wo
sometimes soft and pulpy. When dry, it ofte
very beautiful markings, ridges in the Poppy,
Stellaria, wings in the Pine, and hairs in th
plant. In Asclepias, the hairs are collected into
at one end, forming what is called a COMA.
cases the testa consists of both the coverings of
while the tegmen is formed from the substan
nucleus, but their composition is by no means c
Besides these the regular coverings of ever

bryo sac is no longer seen, as the embryo has ts place, and a store of nourishment, constitut- Albumen, has been deposited beside the young This substance, called also the Perisperm, or En- , must not be confounded with the chemical sub- f the same name. Seeds which have an endo-

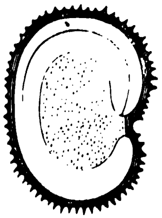
Fig. 231.



Seed of Carex. The embryo is at the bottom seed, the rest is albumen.

re said to be Albuminous (Fig. 231), those which t are Exalbuminous. As to the nature of the n, it is sometimes composed of starch, when it is *ealy*, as in Wheat. Sometimes it is *fleshy*, as in berry; occasionally it swells up into a jelly when (*mucilaginous*), as in the Mallow; and in some in-

Fig. 232.

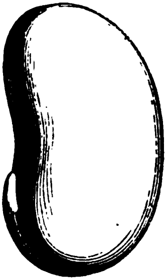


ction of a seed. The embryo surrounds the albumen.

it is *hard* or *horny*, as in the Ivory-nut. When the tegmen pass through the albumen in various ns, so as to give it a mottled appearance when cut, e Nutmeg, the albumen is said to be Ruminated. regard to the position of the albumen, it may eith

surround the embryo—and to this the term PER
more strictly applicable—or be contained within
it is called ENDOSPERM, but both of these terms
employed in a general sense.

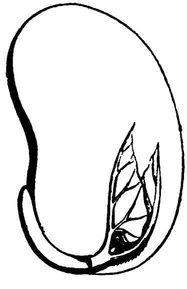
FIG. 233.



Haricot Bean, showing radicle and two cotyledon

EMBRYO.—Occupying the position of the embr
the embryo itself, consisting of a PLUMULE (
RADICLE, and one or more COTYLEDONS. The
always turned to the *micropyle,* the *plumule* a

FIG. 234.



Bean, with one cotyledon removed to show the plum

In plants having an exogenous structure
[illegible]*nally two* seed-lobes, whence the term D

(Fig. 233). Plants having an endogenous structure have one only, and are therefore called MONOCOTYLEDONS.

In many naked-seeded plants (Gymnosperms), such as the Pine, there appear to be several seed-lobes, whence they are called POLYCOTYLEDONS. Plants such as Ferns, which have no true seeds, and so no seed lobes, are called ACOTYLEDONS.

With regard to the position of the embryo, it either occupies the centre of the kernel, when it is said to be *axial*, or it is out of it (*abaxial* or *eccentric*). The embryo is variously disposed in the seed—*straight*, *curved*, *hooked*, *spiral*, or *folded*. When folded, it must either be arranged so as to have the radicle folded over the back of the cotyledons (INCUMBENT), or lying along their edges (ACCUMBENT). Examples of both occur in the Cruciferæ. In some parasitic forms of plants, as the Dodder, the cotyledons are so small as to be undistinguishable.

OFFICINAL SEEDS.

Sinapis	seeds of Sinapis alba and S. nigra (Mustard), contain Myrosine and Myronic Acid	Stimulant and Rubefacient.
Lini Semen **Lini Farina** **Lini Oleum**	from the seeds of Linum usitatissimum	Demulcent.
Amygdala **Amygdalæ Oleum**	seeds of Amygdala communis (Almond)	Demulcent.
Nux Vomica **Strychnia**	seeds of Strychnos Nux Vomica, yield Strychnine	Tonic and Stimulant.
Stramonii Semina	seeds of Datura Stramonium	Sedative and Antispasmodic.
Myristica **Myristicæ Adeps** **Myristicæ Oleum**	got from kernel of seed of Myristica officinalis	Stimulant and Aromatic.
Oleum Crotonis	got by expression from the seed of Croton Tiglium	Purgative and Vesicant.
Ricini Oleum	oil expressed from seeds of Ricinus communis	Purgative.
Cardamomum	seeds of Elettaria Cardamomum	Stimulant and Carminative.
Colchici Semina	seeds of Colchicum autumnale	Used in Gout.
Farina **Bread** ***Amylum***	*from seeds of Triticum* vulgare	Nutritive and Demulcent.

Hordeum — decorticated seeds of Hordeum distichum	Demulcent.
Ergota—diseased grain of Secale cereale	Stimulant to Uterus.
Gossypium--wool attached to seeds of Gossypium herbaceum (Cotton)	Used as a protecting &c.

SEEDS FORMERLY OFFICINAL.

Staphisagria—seeds of Delphinium Staphisagria.	Irritant.
Cydonium—seeds of Cydonia vulgaris (Quince)	Demulcent.
Avena — decorticated seeds of Avena sativa	Demulcent.

SECTION II.

MORPHOLOGY OF THE CRYPTOGAMIA.

PTOGAMIC plants are distinguished from Phanerogamic,
, by the structure of their sexual organs, and the want
owers; and, *secondly*, by their reproductive bodies or
es being entirely deficient of an embryo, and usually
isting of simple cells merely.

he Cryptogamia are subdivided into two great divi-
s—viz., ACROGENS and THALLOGENS; the former charac-
ed by the possession of a distinct stem and leaves,
latter by having stem and leaves indistinguishable.
ong the Acrogens are included Ferns, Lycopodiaceæ,
isetaceæ, Marsileaceæ, Musci, Hepaticaceæ, and Cha-
æ. The Thallogens comprehend Fungi, Lichenes, and
æ.

nother grouping, which is very useful as tending to
g out important distinctions not otherwise recognised,
s follows—

Vascular Cryptogams, including—
  Ferns, Equisetaceæ, Ophioglossaceæ, Rhizocarpeæ or Marsileaceæ, and Lycopodiaceæ.
Non-vascular Cryptogams, including—
  ***a.* Muscineæ = Hepaticæ and Mosses.**
  ***b.* Characeæ.**
  ***c.* Thallophytes = Fungi, Lichens, and Algæ.**

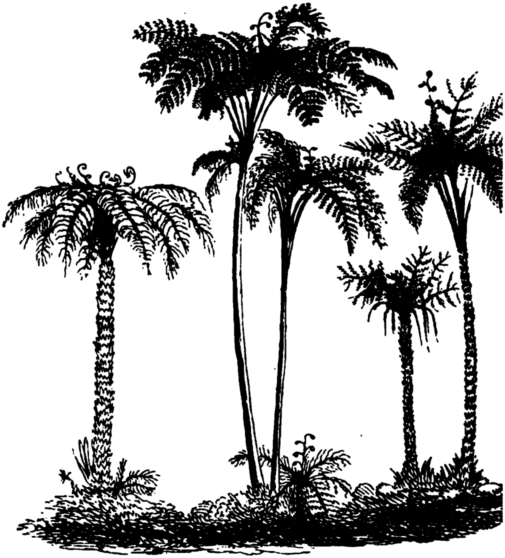
I. ACROGENÆ.

1. *Filices or Ferns.*

mong ferns the leaves or fronds are usually greatly
loped, the stems but slightly so, remaining under-
nd, or on the surface, in the condition of a rhizome,
only forming a true stem or caudex in a few arbores-
forms, found in southern regions. The Rhizomes
r develope in a horizontal or a vertical direction, the
er *give off their leaves* singly at a greater or less dis-
from each other, the latter in tufts. The tufted

condition depends on the non-development of interno and is seen in the *Lady fern*, as well as in the *tree f* (Fig. 235). The leaves or fronds of ferns are often much cut up, and their vernation is *circinate*. Their v tion is also peculiar, being what is called *forked*, an is usually in the forks of the *veins* that the frui seen.

FIG. 235.

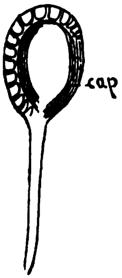


Arboraceous or Tree Ferns.

The Reproductive organs are composed of ca termed *sporangia* (Fig. 236) which are situated o lower surface of the leaf, springing from the nerve usually situated close to the margin. They are u collected into groups called *sori*, which are either or covered with what is termed an *indusium* (Fig *These sori* may be so abundant as to destroy the *leaving* them in the form of panicles or spikes.

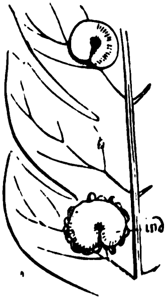
unda. The sporangia are pedicelled, or sessile, and lly surrounded by an elastic ring, on the characters hich the subdivision of the group partially depend.

FIG. 236.



orangium of a Fern.

FIG. 237.



Portion of the frond of a male Fern, showing Sori and Indusium.

se are as follows—

Polypodiaceæ.—These have a vertical incomplete ring.
Cyatheaceæ.—Ring complete, oblique.
Hymenophyllaceæ.—Sporangia surrounded by a cup-shaped Indusium; annulus oblique or transverse, complete.
Gleicheniaceæ.—Sporangia sessile; annulus perfect, horizontal.
Schizæaceæ.—Sporangia sessile; annulus cap-like.
Osmundaceæ.—Ring imperfect, reduced to a group of thick-walled cells.
Marattiaceæ.—These differ from the others in having the sporangia arranged like a several-celled capsule without rings, each opening by a slit or pore.

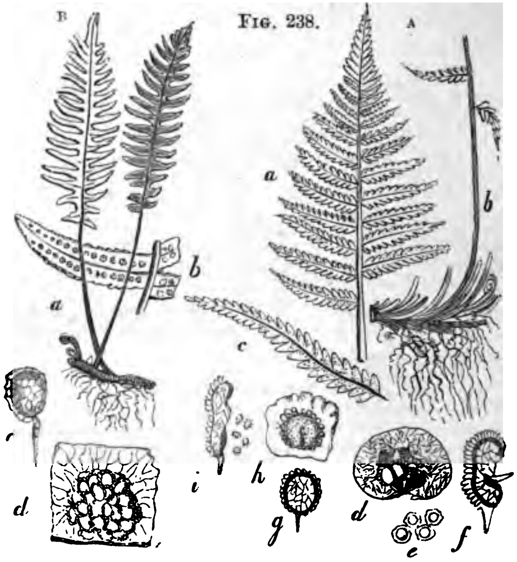
2. *Ophioglossaceæ.*

phioglossaceæ are separated from ferns by various acters. Their fronds are very slow of growth, and no circinate vernation. Their sporangia are ar- ged on a kind of *scape*, where they form a spike or me. The sporangia have no ring, and contain trian- r spores.

3. *Equisetaceæ.*

e Equisetaceæ, or Horsetails, are herbaceous plants lly found *in marshy* places. They have a solid, jointed, subterranean rhizome, from the upper surface of which rise peculiar hollow, jointed, and striated stems of a greyish green colour. The leaves are represented by leaf sheaths and whorls of small scales at each joint. The stems are simple or compound; the secondary axes,

FIG. 238.

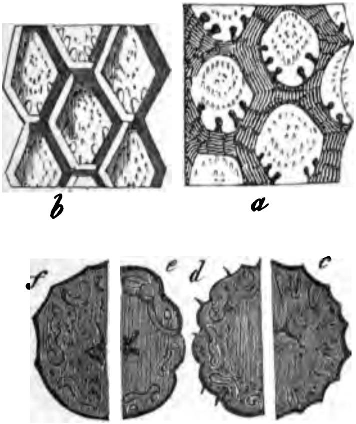


A, Aspidium Filix mas. *a*, Upper part of the frond, showing the rachis and pinnæ, reduced. *b*, The lower part of the frond, showing the rootlets springing from the horizontal stem, or common stipes, with the remains of the old stalks; one in a mature state, and another young one, showing the circinate, or crozier-like vernation. *c*, A fertile pinnule, detached. *d*, An indusium removed with some of the conceptacles attached. *e*, The granules or sporules, discharged from (*f i*) two conceptacles burst by the elastic power of the annuli, spores being discharged. *g*, A conceptacle detached before dehiscence, to show its pedicle and ring. *h*, Ditto, in its natural position.

B. Polypodium vulgare. *a*, Two mature fronds springing from the creeping stipes; also a young frond, showing the circinate vernation. *b*, Fertile pinnule, detached. *c*, A pedicled annulate *conceptacle* detached. *d*, A group or sorus of conceptacles, without *any* indusium.

resent, being given off in whorls at the joints. In ecies the compound stems are barren, while the ones are fertile. When fertile the stem termi- n a club-shaped mass, composed of a short axis ting a multitude of SPORANGIA. The sporangia eath mushroom-shaped bodies. The sporangia, ripe, burst longitudinally and set free the SPORES. ed to the spores are two short extremely hygro-

FIG. 239.



', **Marks left by the decayed fronds on the stems of tree- forming a spurious bark.** *c, d, e, f,* **Transverse section of ms of various ferns, to show the irregular distribution of the es of fibres.**

filaments termed ELATERS, which are supposed to remains of the wall of their mother cell.

preceding groups are characterised by having only *d of spore,* and by the formation of a PROTHAL- n which are developed Antheridia and Archegonia.

4. *Rhizocarpeaceæ.*

A. *Marsileaceæ.*

, the Pepperwort family, consists of small herba- plants *growing in* marshy places. The stem is a slender, creeping rhizome. The fronds are circinate fruit consists of stalked, globular capsules termed CARPS, rising from the bases of the leaves (Rhizoca These sporocarps contain SPORANGIA as well as ant The sporangia emit a single spore.

B. *Salviniaæ.*

These are aquatic and floating plants, with no tru Their fronds have their margins reflexed. Their f cation is inserted at the base of the fronds (Rhizoca Their antheridia and sporangia are in distinct spor

These two constitute the group Rhizocarpeaceæ.

5. *Lycopodiaceæ.*

The Lycopodiaceæ have slender creeping stems, times branching in a bifurcating manner, and roo the bifurcations : their leaves are small and sessile, times whorled. The fruit is in the form of a co the spores are contained in cases, seated in the a the leaves. In Lycopodium there appears to be o kind of spore. In Selaginella the lowest sporange cone produces four *large spores.*

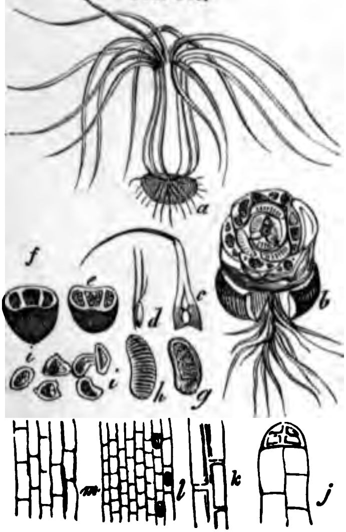
The Isoeteæ are aquatic plants; their stem is corm, producing slender, erect cylindrical leaves, c ing air, from a single bud on its upper surface, and tomous roots from its lower surface. The SPORAN situated at the sheathing bases of the leaves. Those contain macrospores arise from the outer fronds, which contain microspores from those more interna

The Marsileaceæ and Lycopodiaceæ are asso owing to their producing *two kinds of spores:* macro or large spores, and microspores or small spores.

6. *Characeæ.*

The Characeæ are cellular aquatic plants. Their are tubular and jointed; they have no true leaves branches are in whorls at the joints of the stem. antheridia and sporangia grow on branches, som on the same plant, sometimes on different indiv *Their* antheridia contain vesicles, whence spring cha tubes containing spermatozoids. The sporangia are crowned by a 5-rayed corona. The spore is solitary.

FIG. 240.



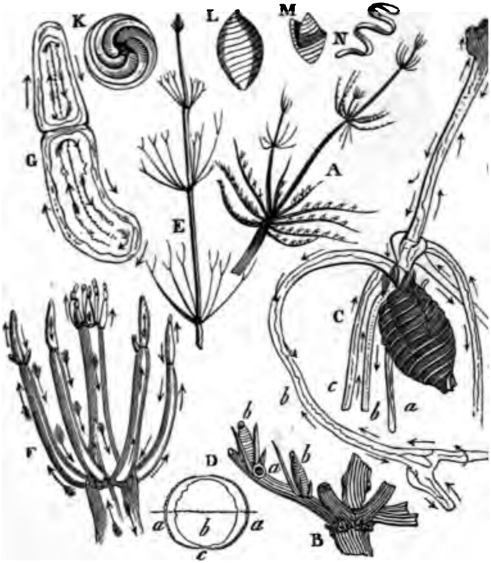
Isoetes lacustris, the lake-quill-wort. *a*, Entire plant, half the natural size. *b*, Transverse section near the bases of the leaves, showing the enclosed organs of fructification. *c*, Front view of one of the external leaves, showing its conceptacle. *d*, Side view of the same. *e*, Transverse section of the conceptacle, showing its three cells filled with granules. *f*, The same, the granules having been removed. *g*, Longitudinal section of one of the inner conceptacles, showing its numerous cells filled with grains. *h*, Ditto, grains removed. *i*, *i*, The grains very much magnified. *j*, Section of a leaf, showing its lengthened cells. *k*, Another section of the same. *l*, Cuticle of the lower surface of the leaf, with stomata. *m*, Cuticle of the upper surface.

7. *Musci, or Mosses.*

Mosses (Fig. 242) have simple filiform, or branched stems, the former erect, the latter creeping. Their leaves are *small, green, cellular* organs, with one or two bundles,

of elongated cells, resembling prosenchyma or v
sometimes arranged in two rows. They are bi
monœcious, or diœcious. The fruit is produced ei

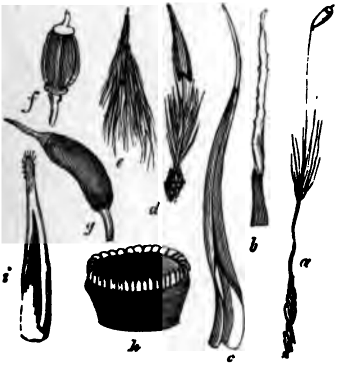
FIG. 241.



A, Chara vulgaris; part of a plant to show the axis and w
branches. B, Small portion at a joint, magnified, to sh
numerous spiral striæ on the stem and branches. *a*, The g
b, *b*, The nucules in the axillæ of the abortive foliage. C, A
portion still more enlarged, to show the spiral valves of the
and the course of the currents in the tubes. D, Transve
tion of a branch, showing the central tubular cavity (*b*) a
meniscoid channels (*a*, *a*), in all of which the fluids move.
lines of demarcation. E, Portion of Nitella flexilis. F,
portion more enlarged, to show the simple tubules. G, A
portion, showing the course of the rotary circulation in e
or tubule. H, I, Longitudinal and transverse sections
stem of Chara hispida. K, L, Gyrogonites, or fossil nuc
Chara. M, Dissection of the nucule of Chara, showing th
coat formed of Spiral valves, and the inner body or spo
its spiral striæ. N, One of the valves of the nucule-case

the extremity of the stem, as in the erect forms, or on lateral shoots, as in those that creep. With the development of the fruit a whorl of leaves termed *perichætium* is formed round it. The Archegonium or female organ of mosses, after fertilization by an antherozoid, begins to develop, and a portion of it termed the nucleus gradually shows. In its growth this carries away a portion of the surrounding organ before it which remains covering the theca, and is called the CALYPTRA. The portion left behind closely encircles the stalk, or *seta*, of the sporange when present, and is termed the VAGINULE. The part within the calyptra swells and forms the *theca* or *capsule*. Besides its outer covering or calyptra, this theca usually has a special lid, called an OPERCULUM, which falls off and allows the mouth of the theca to come into view. This mouth is often surrounded by a fringe of teeth called a PERISTOME. The sporangium contains a central cellular body, or *COLUMELLA*, the remaining space being filled up *with spores*.

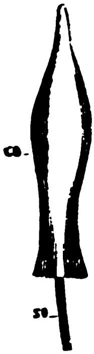
FIG. 242.



Polytrichum. *a*, Plant of P. piliferum, showing the theca and operculum. *b*, Point of leaf. *c*, Whole leaf magnified. *d*, Plant with calyptra. *e*, Calyptra of P. commune. *f*, Urn of the same. *g*, Ditto of P. undulatum. *h*, Mouth of the urn, showing the peristome. *i*, Calyptra of the same.

The male organ, or *antheridium*, is a somewhat r
elongated body, hollow internally, and containing
lage, together with a number of cells (ZOOTHECÆ),

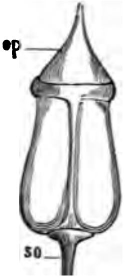
FIG. 243.



Sporangium of Polytrichum covered by Calyptra.

which contains a *spermatozoid*. It ruptures by a
ing at the apex. Surrounding the antheridia th
often a number of slender filiform bodies, termed

FIG. 244.

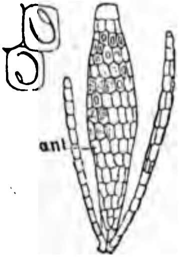


Theca or Sporangium of Polytrichum without the Calypt
so. Seta; op. Operculum.

PHYSES, which are probably abortive antheridia. The spores of mosses are developed in the mother cells by *fours*.

By some Sphagnum is included among the true Mosses, by others erected into a separate group, intermediate in character between Mosses and Hepaticæ.

FIG. 245.



Antheridium of a Moss--cells containing spermatozoids.

8. *Hepaticaceæ.*

There are two kinds of Hepaticaceæ, which differ widely in form. The one form, represented by Jungermanniaæ, closely resembles mosses; the other, or Hepaticæ proper, has thalloid stems and leaves. The Jungermanniaæ have slender creeping stems, like branching mosses, but with the leaves in two rows, so that the stem seems flattened. The Hepaticæ have fronds resembling a sort of thallus, instead of stems and leaves. These are somewhat analogous to the foliaceous stem of the Duckweed. Their sexual organs are ANTHERIDIA, and PISTILLIDIA or ARCHEGONIA. The *Antheridia* are in the axils of the leaves in Jungermannia, in the thickness of the frond in Riccia, and in stalked receptacles in Marchantia; their structure is analogous to that described in Mosses.

In Jungermanniaæ and Marchantiaæ the *Archegonia* are contained in stalked receptacles, while in Ricciaæ they are imbedded in the frond. The sporangia contain no *columellæ* except in Anthoceros, but are accompanied by *ELATERS*. *In Marchantia* the archegonia from the sporangia spring are placed on the under side of peculiar peltate receptacles.

Hepaticæ may also be propagated like mosses by buds, which appear on the surfaces or margins of the fronds.

II. Thallogens.

Thallogens or *Thallophytes* are plants possessing no distinction of parts into stem and leaf, and having no true buds. Their structure is purely cellular, and their forms are only very imperfectly regular.

1. *Lichenes.*

The thallus of Lichens is either in the form of a crust, or it is foliaceous. When crustaceous, it is closely adherent to its support, but when foliaceous it is more or less spreading. Lichens usually grow in exposed situations, and are never aquatic. The thallus is usually dry and coriaceous and consists of two distinct layers: a cortical one, of a greyish colour, and a looser central part, most of whose cells are colourless, but which also contains some green ones called Gonidia. These gonidia are capable of reproducing the plant, like buds or layers vegetatively.

The cortical layer is ordinarily composed of colourless cells of varying thickness.

Beneath this lies a layer of bright green granular bodies; these are the *Gonidia*, and they do not occur in Fungi.

The next or medullary layer may be felted or cellular.

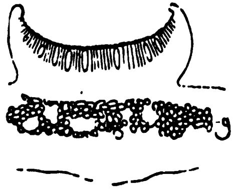
The lowest layer, also called *hypothallus*, is dark in colour and covered with root-like hairs.

Simpler forms of structure are however seen in the group.

The proper reproductive organs of Lichens are of two kinds. One kind, the Spermogones, are small conceptacles embedded in the frond, and opening on the surface by pores. These contain simple or jointed bodies which produce fine acicular filaments called *Spermatia.* These are supposed to be the male fertilizing element. They are not endowed with motion.

The other kind supposed to be female organs are termed *Apothecia,* and are situated on the surface or margin, or are embedded in the substance of the thallus. They are rarely of the same colour as the thallus. The *apothecia* are composed of sporangia or thecæ containing spores.

FIG. 246.



Apothecium of Lichen—vertical section.

These thecæ again are surrounded by club-like filaments or *paraphyses*. Each sporange contains many spores.

Some hold the belief that lichens as a proper group do not exist. They think they consist of groups of Algæ which are held captive in a meshwork by an Ascomycetous Fungus. See Sach's Text-book of Botany.

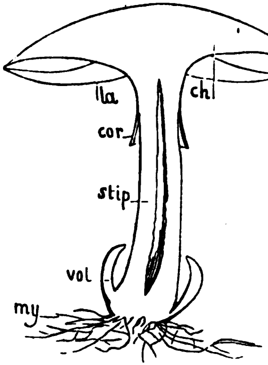
2. *Fungi.*

In this group the sexual and vegetative organs are so much mixed up that they require to be described together. The THALLUS or MYCELIUM, is similar in all fungi, and consists of branched tubular filaments, which contain no colouring matter. This is mostly subterranean, and its filaments may be isolated or form a web-like structure. Fungi vary excessively in size, duration, and texture. They have no organs comparable to leaves or flowers. They are most abundant in decaying organic matters, or as parasites on living beings. They contain no chlorophyll or starch, and their constituents are highly nitrogenized.

In moulds and mildews there is a branching mycelium, from which rise slender filaments terminated by tufts of various coloured spores, free or contained in sacs. These are termed HYPHOMYCETOUS fungi. In some fungi there originates from their spawn or mycelium a sort of fleshy mass, termed a RECEPTACLE or STROMA, in which chambers, termed PERITHECIA are produced. These cavities contain spores, supported on filaments (STYLO-SPORES), or tubular sacs termed ASCI or THECÆ with spores in them. This group of fungi is called PYRENOMYCETES. In others (DISCOMYCETES), the stroma supports organs like the Apothecia of Lichens (Fig. 246), on which stylo-spores and asci are placed.

In mushrooms (Hymenomycetes), a distinct organ, which is merely the fleshy fruit, is supported on a stalk which rises from the mycelium. At first this is contained in a sort of case, called a VOLVA, which is ruptured by the

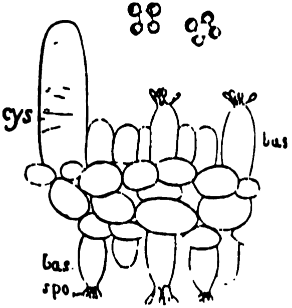
FIG. 247.



Vertical section of Mushroom. *my.* Mycelium; *vol.* Volva; *stip.* Stipe; *cor.* Annulus; *la.* Laminæ (Hymenium); *ch.* Pileus.

development of the Mushroom. The broad, flat portion which rises from the volva is called the PILEUS, and on its under surface are arranged the LAMELLÆ, or GILLS. The Gills are vertical plates, radiating from the centre to the circumference of the pileus, and, taken collectively, are termed the HYMENIUM. Originally this part of the Mushroom is concealed by a sort of covering or INDUSIUM, part of which remains permanently attached to the stalk (*STIPE*), under the name of the ANNULUS. Projecting from the sides of the lamellæ are the spores, supported on little stalks or BASIDIA, and hence termed BASIDIO-SPORES. In some mushrooms no gills occur, other forms of laminæ

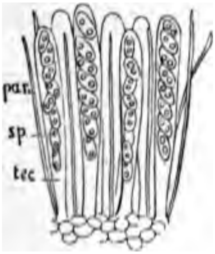
FIG. 248.



Transverse section of a portion of a Lamella of a Mushroom. *cys.* Cystidia or Thecæ; *bas.* Basidia; *spo.* Basidio spores. Spores cut off above the main figure.

or processes taking their place. In Peziza and others, the stalks support not single basidio-spores, but asci, or

FIG. 249.



Fructification of Peziza. *par.* Paraphyses; *sp.* Spores; *tec.* Theca or Sporangium.

cases containing four or eight spores, hence called ASCO-SPORES, or *THECA-SPORES* (*Fig.* 249).

In puff balls, &c. (GASTEROMYCETOUS FUN(leathery coat or PERIDIUM contains when young, voluted lamina on which basidio-spores are dev after a time, however, this lamina decays, so t spores are set at liberty in the interior of the b the Truffle family the laminæ are also irregula voluted, but are not contained in a peridium, a duce *asco-spores* instead of *basidio-spores*.

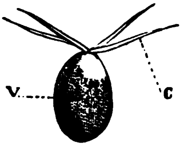
Of the spermatia of fungi little is known.

3. *Algæ*.

This group includes all the lowest vegetabl though mostly marine, some are found in fresh damp places, and many are microscopical. It wil to describe each division of the group separately.

A. Chlorospermeæ, Confervoideæ, or Green In their simplest condition these plants are mere

FIG. 250.



Zoospore with (c) Cilia (Chætophora).

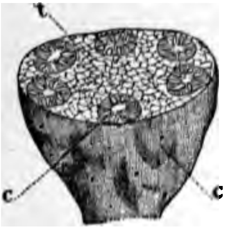
cells which have all the powers of nutrition, r tion by division, &c. The Diatomaceæ are ren for the quantity of silex they contain in their c A somewhat higher condition is as cells arra elongated filaments, which grow either at their ex or by the division of cells nearer the centre. these conjugation is often seen to take place. Ot *Zoospores* (Fig. 250) or *Gonidia*, which are m contents of a cell without the cellulose coat and f with cilia. Some have two kinds of spores, MACR and MICROGONIDIA, the latter being looked upon *matozoids* by some. The Ulvæ are broad as wel and are mostly green.

B. Rhodospermeæ, Florideæ, or Red Algæ vary considerably as to form, some being branched and ilamentous, others even shrub-like, and their consistence varies from the membranous condition to the stony hardness (owing to the carbonate of lime they contain) of the Corallines. Their colours are very various, but never green. They are reproduced by Spores, Antheridia, and Tetraspores.

The Antheridia vary in shape, and consist of a number of cells, each of which contains a spermatozoid. The Spores are either uncovered or in special *sacs* or *conceptacles*, termed *favellæ*, *ceramidia*, or *coccidia*, and consist of two gelatinous coats enclosing a granular mass. The TETRASPORES are naked and isolated, or gathered into groups on the surface of the frond, or contained in cavities called *Conceptacles* or *Stichidia*. A large parent cell (PERISPORE) encloses four *tetraspores*, which are supposed to be analogous to *gonidia*. Zoospores have not been found in this division.

C. Melanospermeæ, Fucaceæ, or Olive Seaweeds.— The appearance of these seaweeds ranges between small

FIG. 251.

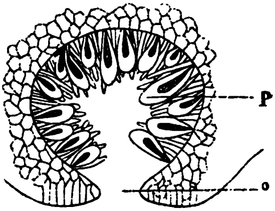


Transverse section of reproductive part of Fucus vesiculosus.
t, Conceptacles; *c*, Openings of these.

tufted filaments and enormous stalks ending in a branched thallus. The higher forms have a shrubby appearance, a distinct epidermal layer, and a kind of root. Their colour is usually olive, never bright green. *Zoospores* are produced in *Oosporangia*, placed at the points or ends of the frond, or in each cell of a filamentous ody termed a *trichosporangium*. The Spores are situated *in sacs called Perispores*. These sporangia or

perispores occur either scattered, or in groups (SORI)
the surface of the frond, or in cavities (*Conceptacle*
Scaphidia) which communicate with the surface b
pore. The conceptacles (Fig. 252) may be collected i
club-shaped masses or *receptacles* at the edges of
frond. The *Antheridia* are ovoid sacs containing

FIG. 252.



Conceptacle of Fucus vesiculosus. P. **Perispores.** *o.* Orifice.

ciliated *Spermatozoids*, and occur on slender filament
the same or other conceptacles as the spores, on the sa
or other plants. When on the same plant with the spo
the plants are said to be *Monœcious;* on differe
Diœcious; in the same conceptacles with the spo
Hermaphrodite. The slender filaments without ant
ridia are called *Paraphyses.*

⁂ Only the merest sketch is here given of, perhaps, he most interesting division of Botany. Anything more would be out of place in a work intended for beginners. Nevertheless, all true lovers of the science of plants are strongly urged to proceed to the study of the Cryptogamia—an unfailing source of instruction and amusement.

PART II.

SECTION I.

PHYSIOLOGICAL ANATOMY, OR VEGETA HISTOLOGY.

As living beings, plants have functions to per
the instruments by which they perform these
ORGANS. Beings possessing organs are said
GANIZED. In the lowest forms of animal and
life, no special organs are set apart for special
but all parts are alike capable of performing
tion, be it nutrition, be it reproduction. In t
forms, however, such specialization does take
is often indicated by some peculiarity of structu
panying the speciality of function. The dist
the parts of plants into roots, stems, leaves, &
parent to all, but to the anatomist each of t
presents varieties of structure peculiar to itself
theless, in the midst of this apparent complexit
really simplicity, for each and all of these parts
can be reduced to one ultimate organic element
to all, and that element is the CELL.

CHAPTER I.

THE CELL.

easy to define a *cell*, more especially as very dif-
eas have become of late years associated with the
m those which used to be attached to it. In
table cell, the external portion of the cell, then
ly called the *cell wall*, was long looked upon as
greatest importance. Now we look to the *cell*
or *protoplasm* as being much the more important
wo. In animal physiology a cell wall, like that
egetable cell, is not usually found, and then we
f a *small mass of protoplasm with or without a*
as a *cell*. In reality the same is the condition in
liest stage of vegetable cells, so that both in
and vegetables we may look on a mass of pro-
of larger or smaller size, as the earliest example
ll, and we might roughly define a *cell* as *the*
particle of living matter which can maintain an
dent existence. This may be *solid*, though later
only assumes the form of a *vesicle*.

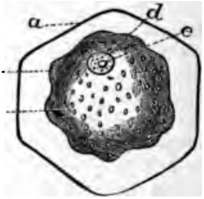
eaking of animal and vegetable protoplasm it is
ry to understand that we do not thereby imply
ntity of the two, but merely their *similarity* as
many *properties* and *functions*. Vegetable pro-
cannot be converted into animal protoplasm
the process of digestion as carried on in certain
animals. But in all instances protoplasm is a
nous compound whether found in plants or
s.

he earliest stage then, as in mature plants when
onsist of a single cell, the cell is made up of these
rts:—1st, an external coat more or less defined—
e *cell wall*, composed of a substance termed *cellu-*
2. The albuminous matter already described and
protoplasm. The outer portion of the protoplasm
l to the cell wall seems denser than the rest, and
ffices to give it a certain shape, when set free from
straint presented by surrounding bodies. This
n of the protoplasm is sometimes spoken of as a (3)

third layer or cell constituent, and termed the *primo* *utricle* or *vesicle.*

In all cell structures, save the very lowest, there is t found a portion of the protoplasm more or less rou in form, and occupying various positions in the cell w seems to be endowed with special properties. This i the *nucleus.* Besides these four cell constituents the

FIG. 253.



a, Periplast; *b*, Primordial Utricle; *c*, Protoplasm; *d*, Nucleus; *e*, Nucleolus.

in all growing cells a very varying quantity of fl termed (5) *the cell sap.* This is either diffused thro the protoplasm, or occupies cavities (*Vacuoles*) in around it. In older cells the protoplasm may enti disappear, leaving the cell walls as mere skeletons. Th cells are to all intents and purposes dead. It is protoplasm which is the true living cell, and out of wh the cell wall is formed.

THE ORIGIN OF CELLS.

It may be broadly stated that at the present mom the general belief is that *all cells originate from* *existing cells.* It is still a question what is the smal portion of protoplasmic matter which is capable fulfilling all the functions of life, and which may t give rise to a new cell or series of cells. This v that namely which upholds the doctrine that an ceedingly small portion of protoplasmic matter ma capable of a separate existence, and be the starting p of a new series of living cells, does away with the cessity of discussing the notions of Schleiden and earlier botanists as to the origin of cells in gran gradually coming together, and so growing into a

The origin of cells and living beings by what is called spontaneous generation is too doubtful to be discussed in a work of the present scope.

Taking it for granted then that cells do only originate in pre-existing cells they may do so in various ways.

1. The whole protoplasmic contents of a cell may escape from its cellulose envelope, and pass from the resting to the active condition. This body after a time becomes fixed and gives rise to a new individual. This mode of origin may be seen in the spores of many Algæ, Œdogonium for example. Here there is neither increase nor decrease in number, but the conversion of one individual into another, a *rejuvenescence* or *redintegration*, what might be called *a renewal of the life of the cell.*

2. In the second mode of cell formation we have two cells uniting together to form a new one. This mode of origin, which may be considered the simplest example of the essential process in sexual reproduction, is also most common among Algæ, the best example being probably found in Spirogyra. Here we find that the cell protoplasm and the cell wall both undergo change. The cell walls of adjacent filaments form protuberances which grow till they meet. The protoplasm re-forms itself, becomes more condensed, and assumes an ellipsoidal appearance. A communication is formed between the two neighbouring protuberances, and the protoplasm of one cell passes through to unite itself with the protoplasm of the other. The new protoplasmic mass is not larger than either of the originals. For a time this rests and then begins to grow, developing a new series of cells. This process, which is called *conjugation*, only differs from sexual reproduction in as far as either cell may unite with the other. Both are morphologically and apparently functionally alike. In many of the Cryptogams the same kind of process is seen, only the male and female elements are more decidedly differentiated. The male element takes the shape of a mobile filament, and unites with the female element to give rise to a cell, the germ of a new plant.

3. A third mode of cell formation is seen in Peziza. Here the protoplasm of the cell originally quite fills it, and is supplied with a nucleus. This nucleus disappears, its substance becoming diffused in the protoplasm. After certain changes a part of this protoplasm becomes differentiated, and certain new cell areas become mapped

out in the protoplasm, leaving a portion of it unchanged. Each of these new bodies ultimately developes into a spore, but a certain amount of the protoplasm of the mother cell is always left unchanged to survive for a longer or shorter period. In this process of cell formation the centres of the daughter cells may or may not be indicated by the previous formation of nuclei. *Here several cells are formed at the expense of one, and the whole protoplasm of the mother cell is not exhausted in the process.*

4. The fourth mode of cell formation differs from the last only in this—that the *whole of the substance* of the mother cell is used up in the process of new cell development. This is the most common, and consequently the most important mode of cell formation. Here, if the mother cell possesses a nucleus, this becomes dissolved and diffused in the cell protoplasm, as many nuclei being subsequently formed as there are to be daughter cells. Or the nucleus of the mother cell divides into two parts which separate, each being surrounded by the portion of protoplasm which is to form its cell territory.

In certain forms of this process there is no great difference between it and that described as the renewal of the cell (1), save that in all cases there is a distinct increase of the members of the family, each mother cell giving rise to at least two or more, probably four, daughter cells. These whilst yet in the interior of the mother cell become condensed and assume a distinctly spherical form, separating from the walls of the mother cell so as to be easily and distinctly recognizable. But there are two kinds or modes of this manner of cell organization. In the one (*a*) there is no formation of a cellulose coat within the mother cell, in the other (*b*) this goes on *pari passu* with the division of the protoplasm as in the growth of pollen in Dicotyledons. The distinction between the two may be readily made out by the use of tincture of iodine. The alcohol causes the protoplasm to contract, whilst the iodine colours it, leaving the cellulose coat where it exists free and uncontracted.

Throughout the whole of these processes the behaviour of the nucleus is as yet not settled. It has been described above as sometimes disappearing or being absorbed in the substance of the protoplasm of the mother cell, sooner or later new nuclei appearing in the divisions of the oplasm of the mother cell which are to constitute the areas of the daughter cells. But in some instances nucleus certainly seems to divide, and the new sions to separate. Possibly this may be the case in instances.

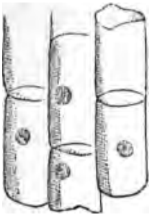
The Growth of the Cell.

rom the time of the formation of a new cell area the ividuality of the cell may be said to commence, and n this period to its maturity the growth of the cell is tinuous. The protoplasmic substance takes to itself material and converts it into part and parcel of its body, and in almost every instance it secretes, or con- ts a portion of itself into, a totally new material—nely, *cellulose*, which constitutes the outer coat or ering of the cell. During the process of growth the commonly undergoes important changes *in shape* as l as *in size*. These may be due either—

(a) *To natural tendencies of the cell;* or
(b) *To pressure from surrounding objects.*

nmonly, to begin with, cells are more or less distinctly nded, but in the course of their subsequent develop- t they may become *elongated*, so as to assume a fili- ı, fibrous or thread-like, bag-like, cylindrical (Fig. 254), ranched appearance. Or, again, they may become and *tabular* as in epidermal tissue.

FIG. 254.

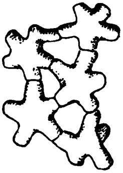


Cylindrical cells (Lily).

ressure also exerts an important influence over the *e of cells. This is* perhaps best seen when many young and fast growing cells are confined within a limited area. Under such circumstances their mutual pressure gives each cell a polyhedral form, which may, however disappear, and the spherical shape be resumed, should the young and unhardened cells escape from their confinement This is frequently seen in the course of reproduction in the Algæ. But no such escape may take place, and so the cells may permanently assume a *polyhedral* outline or, if they are also of the elongated form, may become more or less *prismatic*. A somewhat peculiar modification of cell growth is seen in the loose parts of many plants Here the cells are often of a *stellate* or star shape (Fig. 255)

As the cell grows the protoplasm usually, up to a certain time, increases. With this there is too in most cases a large increase of the cell sap. After a time, however, the protoplasm ceases to increase, and may almost or altogether disappear. The cellulose coat seldom increases equally in its thickness, so that in some places it remains quite thin, whilst in others it forms protuberances of various shapes and kinds. This fact is also to be borne in mind, that the tendencies and characters of the various cell constituents, especially of the cell wall and protoplasm, are widely different, and must be considered apart

FIG. 255.



Stellate cells (Lily).

The variations in the size of cells are very great, sometimes they are very minute, as the spores of some fung which are $\frac{6}{1000}$th or $\frac{8}{1000}$th of an inch in diameter. In th pulp of some succulent fruits, again, they are, comparatively speaking, very large, as in the case of the Lemon whose pulp cells measure the $\frac{1}{100}$th of an inch, which is als about the size of the pith cells of the Elder. Sometim cells attain enormous lengths, as in the fibres of cotton which are single cells, and may measure two or thr inches in length, and in the pollen tubes of some flowers, which are still longer. The average diameter of parenchymatous cells is about $\frac{1}{400}$th or $\frac{1}{500}$th of an inch.

A. The Cell Wall.

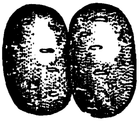
The mode of origin of the cell wall is obscure. That it is formed from the protoplasm is clear, but how it is so formed is not so manifest. But inasmuch as the protoplasm, after the formation of the cell wall, may be readily made to contract, and cleanly leave the cell wall, by alcoholic solution of iodine, it would seem that it is formed by a process of secretion rather than by the conversion of a portion of the protoplasm itself into the substance of the cell wall. The materials of which the cell wall is composed, however, that is, cellulose and certain mineral constituents represented by the ash of plants, must be contained originally in the protoplasm. At all events, the growth of cellulose, whatever may be the case with the mineral matter, is dependent on immediate contact with the protoplasm. When protoplasm disappears cellulose ceases to be formed.

The cell wall grows in two ways, *in superficial area* and *in thickness*. The former process, which corresponds to the period when the cell is undergoing enlargement, and which consequently usually comes first in order, is due to the deposition of new particles of matter between those already laid down, and which form the existing cell wall. If the cell has a tendency to grow in one special direction the new material may be laid down mainly at one point. In the thickening of the cell wall it is only necessary to lay down layer after layer without interfering with those already deposited, though in these also changes may occur.

By variations in the surface growth arise peculiarities as to the *shape* of the cell, whilst irregularities in thickness give rise to *surface markings*, either external or internal. These surface markings are often important. Externally they commonly assume the appearance of *knobs*, *spines*, or *warts*, or if arranged in bands, *ridges*, *combs*, and so on. The internal thickenings are more important. It comparatively seldom happens that the thickening of the cell wall is uniform. Sometimes only a few spots are left *uncovered during* the process, and the cell acquires a *dotted* or *pitted* appearance (Fig. 256). Or, again, the thickening deposits may form rings or bands, giving rise to *annular* and *spiral* cells, or even to a kind of *lattice-work* arrangement by the branching of these (Figs. 257 and 258).

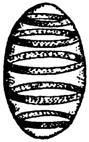
If these thickenings be very strong, and the intervening cell wall thin, the cell wall may give way entirely, and the thickenings be set at liberty as single *rings*, or as what are sometimes called *untwisted spiral vessels* (Fig. 265). When the thickening of the cell wall is very marked, the spaces uncovered by the additions to the thickness of the cell may be so deep as to resemble channels in the thickness of the wall of the cell, closed externally by the original cell wall. By shrinking this outer covering too may disappear, and so a direct communication between the outside and the interior of the cell is sometimes opened. These so-called *pits* in cell walls tend on the whole to a spiral arrangement, but several important deviations from this rule occur. Occasionally these pits occur in a group, the group being surrounded by a dense ridge of uniform

FIG. 256.



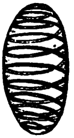
Dotted cells.

FIG. 257.



Annular cell (Mistletoe).

FIG. 258.

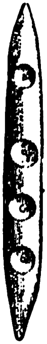


Spiral cell (Orchid).

[This gives rise to an arrangement like a sieve, such cells are named *sieve* cells.

eviation from the broad rule as to the arrange- is to be seen in the Pine family. There, when ng process begins, comparatively large areas ɔvered, but as the process advances, the new ıe more and more extensive, so that the newer ırch the older at the points originally left This may go on till only a minute channel is ed in the thickness of the cell wall. Looking such a thickened cell, the ap- a double or even triple circular y be presented. The outer and ı will indicate the original un- rea of the cell wall; the central the circumference of the channel ns permanently in the cell wall; cumference is greater at one end ıer two circles may be then pro- h a process always goes on in two ls at points exactly opposite each ıat when the original cell walls ı—as they often do—a small ıvity is formed communicating h the interior of either cell. r of cell is known as the *bor-* l (Fig. 259).

Fig. 259.



Coniferous Woody Fibre.

yet another variety of cell wall is seen. Here the thickening laid down in transverse bars perpendicular lines at the angles thus giving them a ladder-like appearance. are consequently termed *Scalariform*, or ɔells; these too may present the bordered ;.

ıels just described as sometimes existing in ıs of the cell wall often present a branched ;, the apparent branches being directed out- ılly, this indicates the coalescence of several o one.

urse of the growth of the cell wall a certain ; of its particles becomes visible. The simplest *Stratification*, whereby the thickness of the ɔms *to be* made up of a certain number of concentric layers denser and less denser. Certain lines become visible on the surface of the cell, usually runni vertically or obliquely. Such markings are called *Str tions.*

Two lines of striation always cut each other at an ang so that the lines of stratification and striation may considered as analogous to the cleavage of a crystal three directions.

In the older cells certain peculiar changes are effec in the cell wall, whereby it is converted into a *co* substance, as in many epidermal cells; into *wood,* as ordinary woody cells; or it may be into a *mucilagin* substance capable of swelling greatly by the imbibition water, as is well seen in Algæ. This is altogether dependent of the deposit of earthy salts, or of silica, in t substance of the cell wall.

B. CELL CONTENTS.

a. Protoplasm and Nucleus.

The *protoplasm* or true living body of the cell consi mainly of albuminous material, with a certain varyi proportion of inorganic matter. But besides this it m contain, in the young cell at least, the elements out which the cell wall is formed, and also the elements of t starch and oils so commonly met with in some portion other of the period of cell life.

In consistence protoplasm is usually of a soft, alm gelatinous character, easily moulded and not readily to but tending to preserve any character impressed upon by surrounding objects. In other instances it may much stiffer, or it may be almost fluid, but in no ca though giving the impression of a flowing movement, c protoplasm be considered as a fluid, inasmuch as movements take place in accordance with vital not w merely physical laws. We may, however, have to deal w protoplasm in two states—namely, as *living protoplas* and as *dead protoplasm.* The two conditions may be w understood by studying protoplasm before, and aft being exposed to the heat of boiling water, which coag lates it like other albuminoid bodies.

Free masses of living protoplasm speedily form on th *surfaces* a thin skin or pellicle of their own substan lled the *primordial utricle.* Another dif- s seen in the formation of a central mass leus. This structure, which does not appear onstitution from the rest of the protoplasm, entral in situation but is the centre of the s of the cell. Occasionally differentiation nucleus itself, just as it more commonly substance of the protoplasm, and to the lies formed in the nucleus the name of metimes given.

most striking and characteristic properties m is its power of *spontaneous movement.* ts concerned in the processes of growth and ape are too slow to be visible, but in many movements of protoplasm are easily enough

movements occur in two different situa- ere the protoplasmic mass is free and, 2nd, nfined within a cell wall.

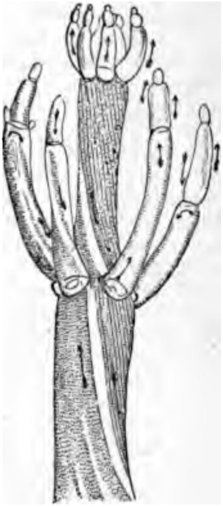
ement of free protoplasmic masses may take ways :—

res of many Algæ, and the bodies called s, have the power, for a certain period, of free eous movement, commonly by means of tions of their own substance called *cilia.*

instances we see that peculiar motion called en the protoplasmic mass seems to flow in direction, constantly changing its shape out tentacle-like bodies in advance. Should encounter an obstacle of suitable size it may l around it, investing it with a covering of ance.

hen confined within a cell wall the proto- ntinue mobile. When the protoplasm has form vacuoles filled with cell sap, motion o take place in that portion of the protoplasm e cell wall, and also in the bands of proto- etween the various vacuoles. Such motion is *tion.* Not unfrequently in the same slender s of granules may be seen flowing in exactly tions. This is common in hairs, as those of Mallow, &c. When the protoplasm forms layer on the surface of the cell wall, the nterior being occupied by a single cavity, the *plasm may* be seen to revolve in one special direction, round the interior of the cell wall, usually in the longest direction of the cell. This gives the appearance of a broad current flowing round and round the cell, and is hence named *rotation* (Fig. 260). Such phenomena are common in many water plants, but are best seen in Vallisneria, Nitella, Chara, or the American pond-weed, now so common.

FIG. 260.



Protoplasmic motion as seen in Chara.

β. *Chlorophyll.*

Chlorophyll is the green colouring matter so universally diffused in the Vegetable Kingdom. It may be said to consist of two portions, a protoplasmic basis and an impregnation of green colouring matter. The latter may be removed from the former by dissolving out the *colouring* matter by alcohol, ether, chloroform, and many *oils* well known as solvents. The conduct of chlorophyll dies is then to all intents and purposes that of small articles of protoplasm.

In some Algæ these chlorophyll bodies assume par- cular forms, but most commonly they are rounded or olygonal. In the course of the life history of the plant time comes when the chlorophyll is absorbed. This best seen just before the fall of the leaf. Other colours an green are produced by coloured fluids, sometimes alled *Chromule*, and some plants which contain chloro- hyll may not be green, the colour of the chlorophyll eing obscured by that of the coloured sap. In Algæ nd Lichens, however, the chlorophyll is mixed with ther colouring matters, producing the peculiar colours een in these plants.

In autumn, it often happens that the chlorophyll un- ergoes changes in colour before the fall of the leaf. till more is this noticeable in the ripening of fruits.

γ. *Crystalloids.*

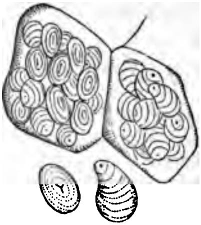
In some plants matters clearly of a protoplasmic ature, and giving all the reactions of protoplasm, are to e found which, nevertheless, do not present the rounded urfaces and blunt edges of protoplasmic material. They re in fact bounded by the same faces, lines, and angles, as re crystals, and are hence termed *crystalloids*. They seem be composed of two different kinds of material, the one ore soluble than the other. Their shape varies greatly, nd they often contain colouring matters. They are to e found in the tubers of potatoes, and in various other tuations.

Yet another form of albuminoid matter is to be seen in e shape of small granular bodies, common in many eds. These have been named *Aleurone*. They seem be destined for the future use of the plant.

δ. *Starch.*

As among animals excess of nourishment becomes de- sited in various situations as fat, so among vegetables ere seems to be a similar accumulation of starch. *Starch* nsists of grains possessing a definite structure and pre- nting *an arrangement in* concentric layers. Each starch granule originates in the cell protoplasm and grows in it. Each also is made up of two kinds of material, *starch granulose* and *starch cellulose.* The former is more soluble than the latter, and is readily turned blue by the action of iodine. Starch cellulose, which constitutes the basis or skeleton of the granule, is more closely allied to ordinary cellulose than the other, their chemical composition being nearly identical. All starch granules contain besides the above some mineral matter or ash, and a varying quantity of water. This water is most abundant towards the interior of the granule, where is situated what is termed the *hilum* or *nucleus.* By the variation of the quantity of water at different depths in the granule its layers are rendered visible. These layers are not, however, always concentric, nor is the nucleus always in the centre. Very small starch granules are nearly spherical, but in the larger the growth is generally more towards one end or side of the granule, giving it a different character. In this way at one end of the granule a considerable number of layers may be seen, whilst at the other or undeveloped end they may be hardly discernible. Apparently starch granules grow by intussusception. This would seem to be indicated by the fact that the outer coat is always the hardest. Moreover the nucleus is soft, and even the youngest grains are hard. Not unfrequently there may be found a double nucleus in young granules, round each of which concentric layers are deposited so as to give rise to a *compound granule.* In the parenchyma of some quickly growing plants, as

FIG. 261.



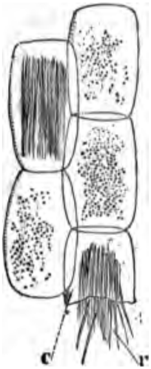
Cells containing Starch, and Starch Granules (Pea).

itaceæ, even more perfectly multiple grains may ıed.

ε. *The Cell Sap.*

sap is found in two different conditions, either ıly diffused through the protoplasm of the cell which ərs more or less watery; or it is found occupying uoles which have been formed in the protoplasm. ll sap represents the fluid nourishment of the cell; once a general solvent, and a chemical constituent, y of the products of cell life. In rapidly growing p is always unusually abundant. In the cell sap are und various substances in solution. One of these, , which is closely allied both to starch and sugar, precipitated either by cold or by abstraction of In this shape it resembles small, more or less, al granules, but it may also be thrown down as

Fig. 262.



Raphides. c, Cell wall; r, Raphides (Rumex).

with radiating lines similar to what may be pro-
y allowing a crystalline body to consolidate in a fluid.

: *crystalline deposits* are common. *Calcium* car-
is *to be found* in many plants, usually in the

granular form. Some marine Algæ are perfectly rigid from such deposits. Occasionally, as in certain members of the Nettle family (Urticaceæ), there are growths of cellulose projecting from the cell wall into the interior of the cell. On or in these growths, crystals of calcium carbonate are sometimes formed so as to project from them in every direction. These are termed *cystoliths*. *Calcium oxalate* is another earthy salt common enough in plants, even more common than the carbonate. It is found in Lichens, most Fungi, and in many Phanerogams. In the last named group the salt occurs in two forms, either as large, more or less, perfect crystals, or more commonly in the shape of parallel bundles of needles called *raphides* (Fig. 262).

The term *Biforines* has been given to certain cells which contain raphides, and at a certain period expel their contents.

OFFICINAL VEGETABLE SECRETIONS.

JUICES.

Opium—juice exuding from the cut capsule of Papaver somniferum; contains the officinal alkaloid Morphia		Astringent, Stimulant, Sedative, Narcotic.
Kino—hardened juice of—		
Pterocarpus marsupium (Indian)...	contain Catechin & Tannin	Astringent.
Pterocarpus erinaceous (African)...		
Eucalyptus resinifera (Bot. Bay)...		
Limonis succus—juice of the fruit of Citrus limonum (Lemon)		Antiscorbutic and Refrigerant.
Elaterium—deposit from the juice of the fruit of Ecbalium officinarum...		Drastic Hydragogue, Cathartic.
Manna—concrete juice of Fraxinus ornus and F. rotundifolia		Sweet Demulcent and Laxative.
Mori succus—juice of the ripe fruit of Morus nigra (Mulberry)		Refrigerant.
Saccharum—refined juice of Saccharum officinarum (Sugar-cane)		Sweetening agent.

JUICES FORMERLY OFFICINAL.

Rhamni succus—juice of the fruit of Rhamnus catharticus (Buckthorn)	Purgative.
Lactucarium—inspissated juice of *Lactuca* virosa and L. sativa (Lettuce)	Sedative.

GUMS.

antha—gummy juice, hardened, Astragalus verus	Demulcent, &c.
—exudation from the bark of an cacia	Demulcent.

GUM RESINS.

ogia—gum resin obtained from a arcinia (Siam) and from Hebra- ndron gambogioides (Ceylon)	Drastic Purgative.
a—exudation from the bark of alsamodendron myrrha	Stimulant.
—exudation from Canarium com- une	Local Stimulant.
etida—exudation from the living t root of Narthex Assafœtida	Stimulant & Antispasmodic.
num—gum resin got from an un- nown plant (Galbanum officinale?)	Stimulant & Antispasmodic.
niacum—exudation from stem and dicels of Dorema Ammoniacum	Stimulant and Expectorant.
nonium—exudation from the cut ot of Convolvulus Scammonia	Purgative.

GUM RESINS FORMERLY OFFICINAL.

um—exudation from Boswellia rrata	Little used.
enum—source unknown	Little used.

RESINS AND OLEO-RESINS.

hylli resina—resin extracted from odophyllum peltatum	Cholagogue Cathartic.
um—resin obtained from the ood of Guaiacum officinale	Stimulant, &c.
he—resin from stem of Pistacia entiscus	Masticatory.
a—oleo-resinous exudation from opaifera multijuga, &c.	Stimulant to mucous membranes.
scammoniæ—resin got from m-resin or root of Convolvulus ammonia	Purgative.
jalapæ—resin obtained from root bers of Exogonium purga	Purgative.
—residue after distilling oil of rpentine from the turpentine of rious pines	Stimulant.

Terebinthina Canadensis — oleo-resin from the stem of Abies balsamea...	Stimulant.
Thus Americanum—hardened turpentine of Pinus tæda and Pinus palustris	Stimulant.
Pix Burgundica—resinous exudation from the stem of Abies excelsa......	Slightly stimulant.

FORMERLY OFFICINAL.

Terebinthina Chia—exudation from Pistacia Terebinthus........................	Stimulant &c.

OFFICINAL BALSAMS.

Balsamum Peruvianum—fluid balsam from the incised trunk of Myrospermum Pereira	Stimulant and Expectorant.
Balsamum Tolutanum — solid balsam from the trunk of Myrospermum Toluiferum	Stimulant and Expectorant.
Styrax—liquid balsam got from Liquidambar orientale	Stimulant and Expectorant.
Benzoinum—hardened balsam got from Styrax Benzoin	Stimulant and Expectorant.

OFFICINAL FIXED OILS.

Lini oleum—oil expressed from the seed of Linum usitatissimum...............	Demulcent
Amygdalæ oleum—oil expressed from the seed of Amygdalus communis...	Demulcent.
Olivæ oleum—oil expressed from the fruit of Olea Europæa	Demulcent.
Myristicæ adeps—concrete oil expressed from the kernel of the seed of Myristica officinalis	Stimulant.
Crotonis oleum—oil expressed from the seeds of Croton Tiglium...............	Purgative and Vesicant.
Ricini oleum—oil expressed from the seeds of Ricinus communis	Purgative.

OFFICINAL VOLATILE OILS.

Limonis oleum—oil distilled from the rind of the fruit of Citrus Limonum	Stimulant and Carminative.
Rutæ oleum—oil distilled from the fresh leaves and unripe fruit of Ruta graveolens................................	Stimulant, Antispasmodic, and Rubefacient.
Copaibæ oleum—distilled from the oleo-*resin* Copaiba (Copaifera multijuga)	Stimulant.

yophylli oleum—distilled from the unexpanded flower-bud of Caryophyllus aromaticus	Stimulant, &c.
entæ oleum—distilled from fruit of Eugenia Pimenta	Stimulant and Carminative.
puti oleum—distilled from the leaves of Melaleuca minor	Stimulant and Carminative.
si oleum—distilled from the fruit of Pimpinella anisum and Illicium Anisatum	Stimulant and Carminative.
iandri oleum—distilled from the fruit of Coriandrum sativum	Stimulant and Carminative.
ui oleum—distilled from the fruit of Carum carui	Stimulant and Carminative.
thi oleum—distilled from the fruit of Anethum graveolens (Dill)	Stimulant and Carminative.
hemidis oleum—distilled from the flower-heads of Anthemis nobilis	Stimulant and Carminative.
marini oleum—distilled from the flowering tops of Rosmarinus officinalis	Stimulant and Rubefacient.
andulæ oleum—distilled from the flower of Lavandula vera	Stimulant and Carminative.
nthæ piperitæ oleum—distilled from the flowering plant of Mentha piperita	Stimulant and Carminative.
nthæ viridis oleum—distilled from the flowering plant of Mentha viridis	Stimulant and Carminative.
risticæ oleum—distilled from the kernel of the fruit of Myristica officinalis	Stimulant and Carminative.
namomi oleum—distilled from the inner bark of the shoots of Cinnamomum Zeylanicum	Stimulant and Carminative.
nphora—concrete volatile oil distilled from wood of Camphora officinarum	Stimulant, then Sedative.
bebæ oleum—distilled from the fruit of Cubeba officinalis	Stimulant.
rebinthinæ oleum—distilled from the turpentine of Pinus palustris, P. tæda, and P. pinaster	Rubefacient, Stimulant, Diuretic, Purgative, Anthelmintic.
niperi oleum—distilled from the unripe fruit of Juniperus communis	Stimulant and Diuretic
binæ oleum—distilled from the fresh tops of Juniperus Sabina	Irritant.

FORMERLY OFFICINAL.

P. Pulegii oleum—distilled from the *flowering plant of Mentha* Pulegium	Stimulant and Carminative.

OFFICINAL ALKALOIDS AND SALTS OF ALKALOIDS.

Aconitia—extracted from the root of Aconitum Napellus	Sedative and Anodyne—very poisonous.
Morphiæ hydrochloras—extracted from opium	Sedative and Narcotic.
Atropia—extracted from the root of Atropa Belladonna	Sedative and Anodyne.
Beberiæ sulphas—extracted from the bark of Nectandra Rodiæi	Tonic and Antiperiodic.
Quiniæ sulphas—extracted from the bark of Cinchona flava	Tonic and Antiperiodic.
Veratria—extracted from the seeds of Asagræa officinalis (Cevadilla)	Irritant, &c.
Strychnia—extracted from the seeds of Nux vomica or Faba St. Ignatii	Stimulant and Tonic.

OFFICINAL NEUTRAL PRINCIPLES.

Santoninum — extracted from unexpanded florets of Artemisia Santonica	Anthelmintic for round worms.
Digitalinum—extracted from the leaf of Digitalis purpurea	Sedative and Diuretic.

CHAPTER II.

CELLS IN COMBINATION.

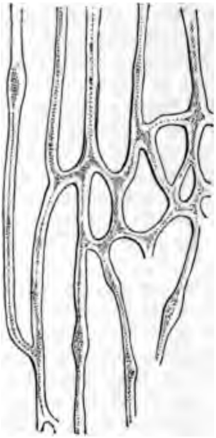
west forms of vegetable life consist of SINGLE CELLS,
ning all the functions which in the higher plants
rformed by complicated organs. Examples of uni-
r plants are presented by the Diatomaceæ, &c.
these in the scale of life come such *collections of*
ı the lower Algæ (Palmelleæ, &c.), where each cell,
ı usually combined with others, when separated
ts neighbours is capable of maintaining an inde-
ıt existence. Such collections are called FAMILIES,
ONIES. In the higher groups of plants the cells,
l of being all similar in shape and function, differ
erent parts, so that one set cannot fulfil the func-
another. Such collections of cells, which also obey
mon law of growth, are called TISSUES.

ues commonly arise by the frequent segmentation
ngle mother cell, and from the beginning are held
er by the existence of a common cell wall. Spurious
ı are formed in certain cases by the amalgamation
regation of cells originating separately. In ad-
cells originating in a common mother cell, the
ning wall is at first a simple partition, and it is
vhen it has attained to some thickness that any
n into two layers is seen. Then only too an inter-
te lamella is seen, giving the idea of a common
llular substance or matrix, in which the cells are
ded. This might almost appear as if secreted by
ll, but is in reality due to the differentiation of what
iginally a common cell wall.

uickly growing cells it not unfrequently happens
the cell tends to assume the rounded, instead of the
ır form, that spaces are created between these ad-
cells. These give rise to what are called *intercellular*
. In some plants these intercellular spaces are
arge and freely communicate, and being filled with
e lightness and buoyancy to the plant. Sometimes
re filled with fluid. Stomata, to be described here-
seem to belong to these intercellular spaces. In

other instances air and fluid channels are to be found, but constructed on a totally different principle. Here by the early absorption of the walls of adjoining cells a kind of pipe or channel is formed. This process of formation is sometimes termed coalescence, and the vessels thus formed are abundantly found in what are called *fibro-vascular bundles.* A series of these vessels, called *Laticiferous* vessels, are formed by a very early and complete coalescence of adjacent cells, so that no trace of the original cells remain, but only simple pipes or tubes freely communicating with each other (Fig. 263).

FIG. 263.



Laticiferous vessels or Cinenchyma.

When in the growth of a plant a uniform mass of cells or *primary tissue* begins to undergo change, the cells usually tend to differentiate. In this way the outer or surface cells tend to flatten, and to assume the characters of an epidermis. Such flattened cells might be termed an *epidermal tissue.*

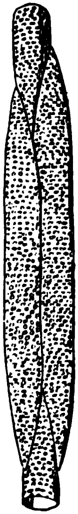
Many of the internal cells retain more or less of their *original* character, modified in shape it may be by mutual

, but not otherwise greatly altered. Such groups ıre commonly styled a *parenchyma.*

;ain number of the original cells tend, however, in ıtances to assume a longitudinal arrangement, that rm fibres or vessels, and as these two forms are ly associated, they give rise to what are called *cular bundles.* This elongated form of tissue is .es called a *prosenchyma.*

arieties of Parenchyma are distinguished as—(*a*) *r*, where the cells vary in size; (*b*), *Regular*, hey more closely resemble each other; and (*c*), *rm*, where they are stellate, or of any other shape

FIG. 264.

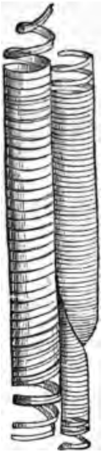


Greatly elongated dotted or pitted cells.

ıllows of large intercellular spaces. A peculiar ' Parenchyma, distinguished by its brick-shaped known as MURIFORM Parenchyma. It occurs in *er grain* of *wood.* Besides these, there is what is called COLLENCHYMA, which is a tissue whose cell contain a mucilage capable of being extracted by wa

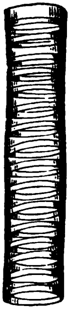
Elongated fusiform cells combined in a tissue c tute PROSENCHYMA. Such cells either merely tou their extremities, or they overlap each other. As exa of prosenchyma may be cited ordinary woody fibre (also PLEURENCHYMA), which is composed of mode long cells, and the liber composed of very long cells, lapping each other at their extremities.

FIG. 265.



Spiral vessels partially unfolded.

FIG. 266.



Annular vessel (Melo

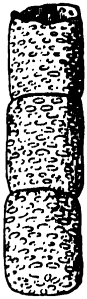
What is called VASCULAR TISSUE is closely allied to senchyma, but it is composed of *dotted* or *pitted, s* *annular, reticulate,* or *scalariform cells.* By the ab tion of the walls where two cells touch each other, cavities become continuous, and produce a tube or c On this account the vessels of plants are *Intracell* those of animals *Intercellular,* seeing that their wall made up of tissues composed of many cells. The vas tissue, composed of dotted or pitted cells (Fig. 264 ranged end to end, so as to form pitted ducts (Fig

called BOTHRENCHYMA. That tissue, made
nnular, *reticulated*, or *scalariform* cells, so
constitute vessels to which similar names
e sometimes called, from the peculiar fibrous
their cells causing them to resemble the
es of insects, TRACHENCHYMA.

37.

ssels (Fern).

FIG. 268.



Dotted or pitted duct (Melon).

itted ducts occur in the wood of Dicotyle-
ited vessels occur abundantly in Monoco-
nular vessels are commonest in the Equise-
alariform vessels in Ferns (Fig. 267), whilst
are found in the delicate parts of most
lly Dicotyledons.

CHAPTER III.

COMBINATIONS OF TISSUES.

Epidermal Tissue.

THE simplest form of cell differentiation seen in plants is the formation of an outer layer of cells differing in shape and characters from the bulk of the cells lying below them. These superficial cells become flatter, thicker, and firmer, and they are frequently also smaller than those of the parenchyma. This distinction is most marked in plants, or parts of plants, freely exposed to the air, much less so in those parts which are underground, or submerged in water.

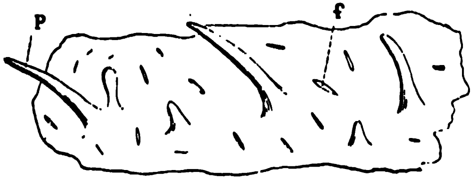
In the lowest groups of plants the only difference between the surface and the deeper cells is that they are smaller and firmer near the surface. The colour too is darker, and they tend to produce hairs.

In vascular plants a perfect epidermis is commonly developed, at first as a simple layer of cells, but this may be subsequently divided into two or three layers. Of these the outer is still recognised as the epidermis. Beneath the true epidermis strengthening layers may exist. Certain of these cells, termed the *hypoderma*, are parenchymatous in their origin, though often presenting a very different appearance from parenchyma cells.

Epidermal cells correspond in shape, to some extent, to the part they cover. Thus if this be elongated they too are chiefly developed in the longitudinal direction, whilst on broad flat surfaces they are usually tabular. Their edges are often sinuous.

On the surface of the epidermis is found the *cuticle* (Fig. 269), which covers not only the epidermal cells, but also the boundaries between them. The outermost layers of the epidermal cells are thus altered, and their surface walls may be greatly thickened, whilst the internal wall is but little altered. Solutions of iodine, with or without sulphuric acid, colour the cuticular substance yellow or brown. With the cuticle are often associated deposits of *wax*. These serve to protect the plant from the penetration *of fluid*, and when peculiarly disposed give rise to what is led the *bloom* seen on certain fruits, as grapes and ums.

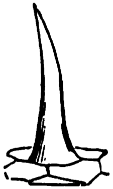
FIG. 269.



Cuticle with hairs, P; Stomata, F.

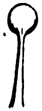
All *Hairs* are strictly speaking epidermal appendages. ey are in their simplest forms mere thin-walled pro- berances from the epidermal cells, and rarely branch ig. 270). From this *type* varying degrees of complexity

FIG. 270.



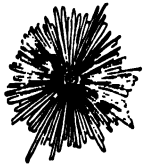
Simple unicellular hair.

FIG. 272.



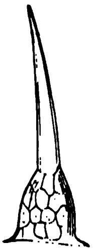
Unicellular glandular hair.

FIG. 271.



Radiating hair (Eleagnus).

FIG. 273.

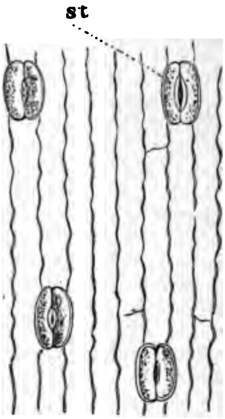


Glandular stinging hair.

arise. The hairs may become shorter, thicker, and stiffer, as in prickles, and may be separated by a septum from the mother epidermal cell. Whilst in yet other cases the number of cells may be much greater, and *compound hairs* result. The shape of hairs is very various. Most frequently they are elongated and more or less pointed, but sometimes they expand laterally, giving rise to more or less distinctly plate-like forms (Fig. 271). When furnished with glandular cells, either at the point (Fig. 272) or at the base (Fig. 273), such hairs are termed *glandular* hairs.

Stomata are among the most interesting of epidermal structures. They do not occur on the epidermis, or what, on account of their absence is sometimes termed the *epiblema*, of true roots, but they may be found on some underground, and more rarely on submerged stems. They are most abundant on leaves and aerial stems, especially on the green parts where chlorophyll abounds, and where an active interchange of gases between the interior of the plant and the outer air is going on. The shape and arrangement of the stomata depend in part on the arrangement of the epidermal cells. Usually they

FIG. 274.



Epidermis and Stomata (Lily).

nsist of two kidney-shaped cells, with their recesses ad-cent to each other (Fig. 274). For their formation a ecial cell appears in the epidermis, which after a time vides in two parts, the line of division being perpendicu-r to the surface. A lamella is formed between these two lls. This lamella is speedily thickened by deposits hich tend still further to separate the two new cells. The mella splits in two, the cuticle is also ruptured, but soon vers both walls of the lamella, and so an opening, which e call a *stoma*, is made into the intercellular system of e plant. The two adjacent cells are termed *guard cells*. Much more complexity may be seen in the formation of omata—especially in the Marchantias—but the above mple description of what is seen in Hyacinths will give a ufficiently clear idea of the process.

In the older plants belonging more especially to Dico-yledons, the epidermis by degrees gives way to a new tructure called *bast*. The cells of this substance, which re usually elongated and filled with air, are singularly esistent, but are flexible and elastic. This layer does ot usually arise from epidermal cells, but from the layer ubjacent to them. Ultimately this may produce a com-lete coating to the stem and branches of the plant.

Fibro-vascular Bundles.

In the substance of the higher Cryptogams, and in all Phanerogams, are to be found certain string-like bodies termed fibro-vascular bundles. These may remain slender, s is well seen in the leaves of the greater Plantain (Plantago major), when the leaf is broken across and the parts severed. Here the fibro-vascular bundles hang out like threads, and are sometimes used by children to "tell fortunes." Again they may grow strong and thick, and in all Conifers and Dicotyledons are so developed as to fill up almost the whole of the stem, leaving hardly any of the original tissue whence they were developed.

In the young state all plants are composed of what ight be called *indifferent cell tissue, fundamental tissue,* r *simple cellular tissue*. With age in the higher plants his undergoes differentiation. Certain of the cells ar-ange themselves longitudinally, and form vessels, wood bres, &c. But without and within this differentiated yer, indifferent cells still capable of development remain and constitute what has been termed a Cambium. Some fibro-vascular bundles in the course of their growth exhaust the whole of their indifferent tissue, and in this way become what is termed *closed*. The growth of such bundles is *definite*. This is the case in the higher Cryptogams, in all Monocotyledons, and in some Dicotyledons. In others, again, the growth is *indefinite*. The cambium is not exhausted, and the bundles remain *open*, and so the bundles may continually be adding to their thickness both outside and inside. Such is the rule in Conifers and nearly all Dicotyledons.

In a differentiated fibro-vascular bundle the tissues may be grouped, as the bast (*phlœum*) portion, and the woody (*xylem*) portion. The cells of the bast layer are usually thin walled and succulent, or long and flexible. These thin-walled cells may be parenchymatous, or may be lattice cells, or tubes with sieve-like markings. The woody portion again has its cells thickened with woody matter, and its vessels often contain air. In open fibro-vascular bundles it is common to find rows of cells developing horizontally or radially as well as longitudinally. These cells, which are commonly parenchymatous, may become hard and woody and constitute the so-called silver grain of wood.

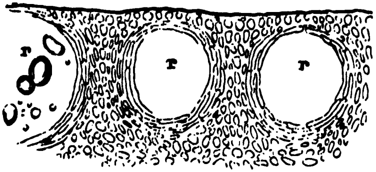
Indifferent Tissue, Cellular Tissue, or Fundamental Tissue.

This term may be given to the cellular mass out of which the epidermal and fibro-vascular systems are developed, or to that portion of it which remains after they have been developed. The cells of it are usually thin walled and succulent, constituting a parenchyma more or less permanent. It is of such tissue that all Thallophytes and some Mosses are formed, whilst in vascular plants it fills up the interstices between and within the fibro-vascular bundles, and in certain plants may constitute the largest part of the stem. Usually in Dicotyledons we find this tissue divided into two portions, a central lying within the fibro-vascular bundles or *pith*, and a peripheral or *cortical portion* lying without them. Between the central cellular tissue or pith and the cortical cellular tissue extend what are called *medullary rays*, composed of the same material.

Glands and Sap Vessels.

he vessels which are found in fibro-vascular bundles formed, as already seen, by the arrangement of cells in s, and the absorption of their intervening walls. se vessels in the mature condition only contain air. ticiferous vessels are formed in the same way, but their lls are thinner, and they often branch. They are most indant in the bast layers of the fibro-vascular bundles, may occur elsewhere and in various situations. They ays contain a milky-looking juice. Closely resembling se, though different in origin, are the intercellular ces forming a system of canals, and containing ious kinds of juice. Glands differ from all these in ng purely local formations. They may consist of gle cells; or of groups of cells, whose adjacent walls ve broken down, and which constitute a common re- tacle for the special substances formed by the cells ig. 275).

FIG. 275.



Internal glands (Orange rind).

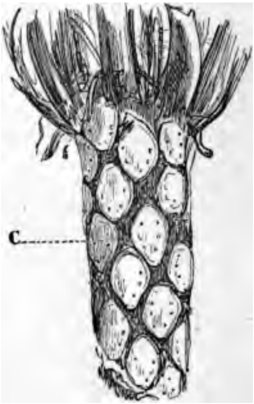
THE STRUCTURE OF GROWING PLANTS—STEMS.

At the growing point in all plants, whether in the anches, leaves, or roots, the cells are in an unformed ndition. They are capable of growth; and in the higher ants of differentiation, whilst as the differentiation goes and special tissues are formed, the undifferentiated cells e constantly being renewed at the growing point. This formed tissue is sometimes called Primary Meristem, d it always occupies the growing point or *punctum vege- tionis* of a plant. In most Cryptogams the growing int is terminated or capped by a large *apical cell.* By e segmentation of this cell other cells are formed, which ay afterwards become differentiated. In Phanerogams there is *no single apical cell,* the punctum vegetationis is multiple.

Algæ are entirely made up of cellular tissue, but the cells on the exterior of these plants are smaller than those in their interior, so that they appear to have a kind of epidermis.

In many Mosses, the central part of the stem is occupied by a bundle of elongated cells, which, in some genera, become actually prosenchymatous, but *no* vessels are to be found.

FIG. 276.



Rhizome of Fern with cicatrices, c.

The Lycopodiaceæ have a distinct fibro-vascular bundle in the centre of their stems, their vessels being mostly of the *spiral* kind. In the Equisetaceæ there is a ring of fibro-vascular bundles surrounding the cellular tissue, which constitutes the greater part of the stem; but the vessels in this case are mostly *annular.*

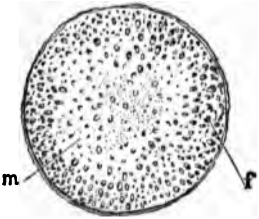
The fibro-vascular bundles (Fig. 276) seen in Ferns, are still more marked; they do not pursue a straight course, but have a wavy or netted appearance, and join each other at the points where branches are given off to the leaves and roots. Their vessels are referable to the *scalariform* type.

n Phanerogams two well-marked kinds of stems occur, rding as these are made up of closed, or of open fibro-ular bundles. From certain peculiarities in their le of growth, the two kinds of stems are also known ndogenous and Exogenous stems.

A. *Endogenous Stems.*

n this group, of which the Palm may be taken as type, e is a general pith in which curved fibro-vascular dles of the closed or definite kind are arranged in a liar manner. These bundles (Fig. 279) do not anas-ose with each other as they do in ferns, and they pass ly into the leaves with which they are connected at

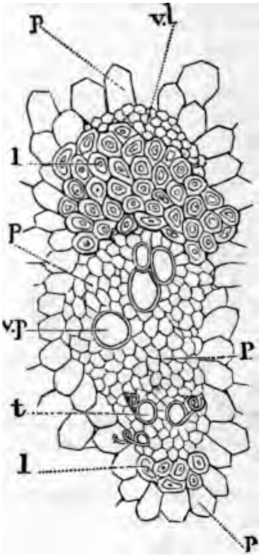
FIG. 277.



Horizontal section of a palm stem. *m*, Parenchyma; *f*, Definite fibro-vascular bundles.

r upper extremities, while at their lower end they bend wards, and then interlacing, form a sort of network sepa-ng the cortical from the central parenchyma. In Her-eous Monocotyledons the stem consists of a succulent enchyma, with stringy fibrous bundles diffused through nd even in those possessing *woody* stems their hardness s not so much depend on the fibro-vascular bundles on the woody transformation of the parenchyma. nocotyledonous stems are bounded on the outside by a l, which, however, does not correspond with the bark of genous plants. It consists of a loose parenchyma, ered by a few layers of tabular cells, corky in their tex-e when most developed; but in some cases this layer made up of a single layer of flattened cells. These stems are called Endogenous from the peculiar mode in which their fibro-vascular bundles (Fig. 278) are developed. They originate at the punctum vegetationis, or organic apex of the plant. From this they bend outwards in two directions upwards towards the leaves, and downwards towards the roots, or if the stem be of any great length, they reach the rind before they get to the root, the upper curve being much the more abrupt of the two. Formerly it was supposed that there was only one curve—viz., that towards the leaves, and that the bundle afterwards went straight from the apex to the root of the plant inside all the bundles previously developed. On this account, that

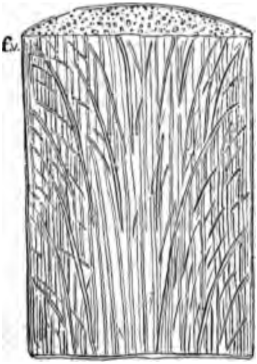
FIG. 278.



Transverse section of the closed or definite fibro-vascular bundle of a Monocotyledon. *t*, Spiral vessels; *v p*, Pitted vessels; *p*, Parenchyma; *l*, Thick-walled fibre cells, bast and woody; *v l*, Laticiferous vessels. The inner portion is lowest.

the supposition that the newest part was most
l, the stem was called ENDOGENOUS. The lower
ities of these bundles are intimately connected with
d, which cannot, therefore, be separated from them.
outer part of such stems contains most fibro-
r bundles, it is harder than the internal portion,
osite being the case in Dicotyledonous stems. As
rtical portion soon hardens, the stems become
ble of increasing their diameter at an early period,
e, therefore, usually cylindrical. In some cases, as

FIG. 279.



ertical section of a portion of a palm stem. *f v*, Fibro-vascular bundles.

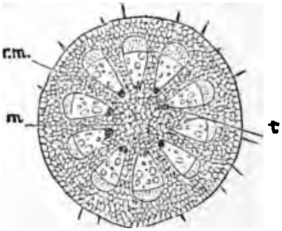
Dragon-tree (Dracæna), this hardening does not
lace, so that the stems have the conical shape of
ns, and are capable of attaining a great size. En-
ous stems have usually but one bud (a terminal
o that when it is destroyed the plant dies; but in
as the Doum Palm, two are produced, while on the
n-tree, Asparagus, &c., many buds are developed.

B. *Exogenous Stem.*

otyledons, at an early period of their history, con-
f a primary cellular tissue or parenchyma, regular
egular as regards the size and shape of its com-

ponent cells. Within this is developed a circle of open or indefinite fibro-vascular bundles, anastomosing with each other, so as to form a sort of network, the meshes of which are filled with bands of cellular tissue connecting the central parenchyma with that more external. Between the fibro-vascular bundles and the outer surface lies the cambium layer, and the whole is covered by the epidermis (Fig. 280).

FIG. 280.



Horizontal section of the stem of the Melon. *m*, Pith or central parenchyma (primary). *t*, Spiral vessels; *r m*, Medullary rays. Outside the fibro-vascular bundles is the external parenchyma.

At this period, therefore, exogenous stems are composed of—

1. Internal Primary Parenchyma,
2. Open Fibro-vascular bundles in circles,
3. Cambium layer,
4. External Primary Parenchyma,
5. The Epidermis,

Medullary rays.

Such is the permanent condition of herbaceous Dicotyledons; but in those intended for a longer existence than one or two years, it is usual to find a somewhat more complex structure.

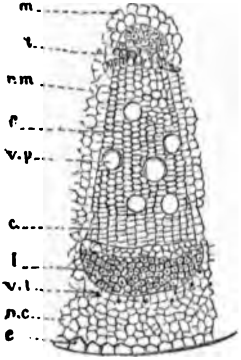
Here also there is a central pith, composed of spherical, dodecahedral, or stellate cells. In plants one or two years old the pith is not so large, relatively to the rest of the stem, as in very young or herbaceous plants. In plants which grow rapidly, such as the Umbelliferæ (Hemlock, &c.), a sufficient number of cells cannot be produced to occupy the space intended for the pith, so *that*, except at the root, the stem is hollow.

The same is the case in the endogenous stems of Grasses. In the Walnut-tree there is a regular alternation of cavities and septa, producing what is called a *chambered* pith.

The internal portion of the fibro-vascular bundles when they surround the pith contain many spiral vessels. This ring, for such they practically form, is sometimes called the MEDULLARY SHEATH.

The fibro-vascular bundles of which the stem consists are arranged in concentric circles, each of which constitutes a year's growth, or at least a period of rest and a period of activity. These circles are, however, broken up into wedge-shaped masses by the medullary rays running from the pith to the bark.

FIG. 281.

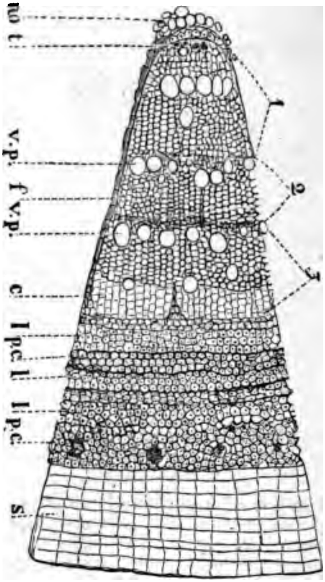


Horizontal section of a portion of the stem of the Melon. *m*, Pith; *t*, Spiral vessels of medullary sheath; *r m*, Medullary ray; *c*, Cellular tissue; *v p*, Dotted vessels; *l*, Liber; *v l*, Laticiferous vessels; *p c*, Cortical parenchyma; *e*, Epidermis.

This cessation of growth in winter is due to the cold; but in tropical countries the cause of the cessation is more commonly drought — for this reason, in such regions, more than one ring may be produced in a plant in one year, while in the Cycas tribe several years are required for the *completion* of a single circle. As a general rule, however, the number of rings in a tree may be taken as indicating its age in years.

Dotted or pitted *ducts* are generally surrounded by woody fibres, but in this, as well as in the sizes of both ducts and fibres, there are many variations. The wood of Conifers is composed almost exclusively of their peculiar *punctated* or *glandular* tissue (Fig. 259).

FIG. 282.

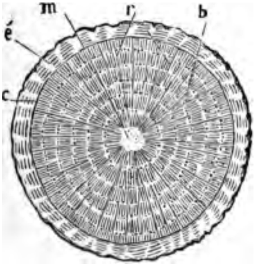


Transverse section of a portion of a three-years'-old exogenous stem. *no*, Pith; *t*, Spiral vessels of medullary sheath; *vp*, Pitted vessels; *f*, Woody fibres; *c*, Cambium layer; *l*, Liber, or Bast layers of the bark; *p c*, Cellular layers of the bark; *s*, Corky layers of the bark.

As the tree increases in size, the older parts of the wood go on increasing in density by the thickening of their cell walls, till at last these become totally imvious, and in a measure dead to the plant. This tral part is termed the DURAMEN, or *heart-wood*, and is m differently coloured from the other parts of the stem, ng to peculiar secretions deposited in it; this is seen Mahogany, Ebony, Lignum Vitæ (the Guaiacum tree),

The outer part, where the cells are not so much kened, is called the ALBURNUM, or *Sap-wood*, as the ds for the nourishment of the plant ascend through it. As has been seen, the wood is arranged in wedges, ich are bounded laterally by the MEDULLARY RAYS. ese rays belong to the horizontal system of the plant, l are composed of thickened brick-shaped cells placed e above the other (hence called Muriform parenchyma),

FIG. 283.

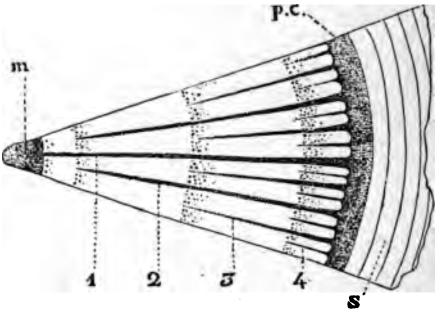


Horizontal section of a six-years'-old tree. *c*, Cambium layer; *b*, Annual rings; *r*, Medullary rays; *m*, Pith; *é*, Bast.

d serve to connect the cellular system of the pith with at of the bark. The rays, stretching the whole way m pith to bark, are called *primary*. But as the iginal wedge of wood increases in breadth year by year, is at the same time cut up by a new set of rays, ig. 283), which only stretch from the ring of the year in ich they originated, to the bark. These are called *ondary* rays (Fig. 284). It also results from the inrlacing of the fibro-vascular bundles of the same circle th each other, that the medullary rays, which pass rough these interstices, do not pass directly and conuously from apex to base of the stem, but have only all *vertical dimensions*. In the heart-wood the brick-shaped cells of the rays become hardened by the deposition of sclerogen within them.

In all dicotyledonous plants there is to be found a layer of cells retaining their protoplasm in a state fit for subdivision, immediately outside the sap-wood, and separating it from the bark. This is called the **Cambium layer**. From this layer are developed the wood internally, and the bark externally, the cells of which it is composed changing into the brick-shaped cells of the medullary rays, the ducts and woody fibre of the fibro-vascular bundles, on the inside; and on the outside, the long and slender fibres of the liber take their origin from the same source. It is to its presence that Exogens owe their peculiar property of unlimited growth, for when it is destroyed at any part there is a deficiency in the woody ring corresponding with the deficient Cambium. The colour of the Cambium layer is green.

Fig. 284.



Transverse section of part of a dicotyledonous stem showing medullary rays of four degrees. *m*, Pith; *p c*, Cortical parenchyma; *s*, Bark.

The structures outside the Cambium go by the collective name of Bark, but may be divided into four sets— viz., from within outwards.

1. The *Endophlœum*, or *Liber*.
2. The *Mesophlœum*, or *Green Cellular Layer*.
3. The *Epiphlœum*, Corky, or *Suberous Layer*.
4. The *Epidermis*, &c.

ere the prosenchymatous structures are internal, the llular external, the reverse being the case in the wood; e bark also grows from the inside, instead of from the tside.

Immediately outside the Cambium comes a layer which very many respects resembles the woody layers inside. is the inner layer of the bark, whence it is called the NDOPHLŒUM; and as it was formerly used for writing n, it is also called the LIBER. The name *Bast* is also iven to it. It is composed of very long and slender and ot too greatly thickened prosenchymatous cells, rounded r hexagonal in section, the wood-cells being, on the other and, most frequently square. The cells are generally imple, but sometimes they are branched. From the longated cells of the liber and the spiral vessels of the edullary sheath the fibro-vascular bundles of the leaves re formed. It is from this layer that most of our textile abrics are got—flax, hemp, jute, &c. On account of their rigin such substances may be readily distinguished from otton, by their exhibiting the peculiar cellular structure f woody fibre, whilst Cotton is the unicellular hairs ttached to the seeds of the Cotton-plant. Like the wood, he liber is reticulated, to admit of the passage of the edullary rays, and presents a smooth surface to the ambium, but is rougher where it joins the next layer of the bark, or MESOPHLŒUM. This consists of cellular tissue, with the cells more or less flattened, and containing Chlorophyll. It is connected with the pith by the medullary rays which end here. Outside this comes the corky layer of the bark, called from its position EPIPHLŒUM, and consists of layers of flattened cells containing air.

The characters of this *corky layer* vary greatly in different species. Sometimes it is only a thin layer, in other cases it attains a great thickness, as in the Cork-oak; in some cases it is permanent (Elm); in others it falls away periodically (Birch). In the Vine and Clematis, the liber is thrown off with it. Besides these structures the bark contains *laticiferous vessels* in its two inner layers, and is often the reservoir of developed secretions. Hence arises the use of barks in medicine.

The ACROGENOUS stem, as seen in Ferns, might accordingly *be described* as a cylinder of pith surrounded by a network of closed fibro-vascular bundles, ending in a crest of leaves at the top.

The MONOCOTYLEDONOUS or ENDOGENOUS stem, also consists of a cylinder of pith, intersected by curved fibro-vascular bundles of the definite kind, but not forming the regular superficial network seen in Ferns.

The DICOTYLEDONOUS or EXOGENOUS stem consists of a series of cones, the one within the other; the most internal and the most external consist of cellular tissue; between the two the substance of the stem is made up of open or indefinite fibro-vascular bundles.

THE ROOT.

Roots consist of a fibro-vascular axis surrounded by cellular tissue, which when young, is covered by that kind of epidermis which wants stomata, and is called *Epiblema*. In old plants this covering is replaced by a tissue of a corky nature.

According to their mode of origin roots are either *axial*, as in Dicotyledons, or *adventitious*, as in Monocotyledons, and the higher Cryptogams. The former are often woody, the latter more rarely so, being usually succulent, except in arborescent forms.

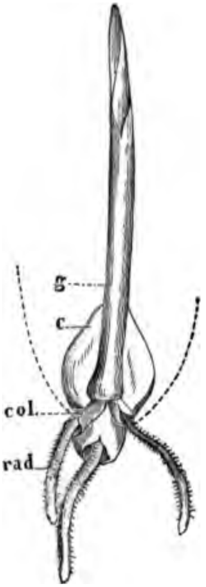
In VASCULAR CRYPTOGAMS or ACROGENS, the rootlets are developed all over the spore. At first such rootlets are only simple cellular processes, but no true roots are ever found where the plant contains no fibro-vascular bundles. Owing to the irregular origin of the roots of Acotyledons, the plants themselves were called by Richard. "HETERORHIZAL."

In MONOCOTYLEDONS the radicle of the embryo is not developed, but in the substance and below the rind of the stem, at its lower part, a number of little conical projections of cellular tissue take their rise. These papillæ make their way through the rind, carrying a part of the tissue before them in the form of a little conical cap, (the root-cap), while part of it remains clasping the rootlet, and forming a little collar round it. The cap is called a *Pileorhiza*, when it is seen as in the Duckweed, the collar a *Coleorhiza*. The whole plant, from the roots originating in this manner, is sometimes said to be *Endorhizal*. The fibro-vascular bundles are of the limited or definite kind.

Pileorhiza is well seen in the adventitious roots of ndanus, or still better in the floating roots of the eed (Lemna).

ndary roots are formed in the same way as are the y roots of a given plant.

FIG. 285.

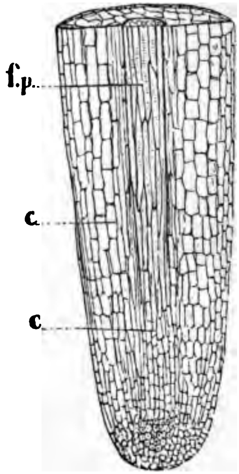


erminating seed (Oat—Monocotyledon). *g*, Plumule; *c*, Cotyledon; *col.* Coleorhiza; *rad.* Radicles.

DICOTYLEDONS, the roots are developed from the , which, like all other parts of the embryo, is lly of a cellular structure. The radicle grows by velopment of cells a short way behind its apex, so e extremity of the root is older and denser than rt immediately behind it.

extremity of the rootlet was supposed by De Can- *to be an organ* whose special function was the absorption of nourishment, and which he accordingly called a SPONGIOLE, or SPONGELET. Its object appears to be the protection of the tender parts below it from injury in making their way through rough soil. It is somewhat analogous to the Pileorhiza already described. In reality it is older, its cells are thicker and denser, and the whole structure less adapted for absorption than the thin-walled cells behind it.

FIG. 286.



Extremity of a root cut vertically. *f p,* Fibrous bundles; *C.* Cellular tissue. The denser and older portion at the extremity is the so-called Spongiole.

The fibro-vascular bundles in Dicotyledons are of the indefinite kind, and by their aggregation at the point where the stem joins the root (the *Tigellus* or *collar*) abruptly end the pith, so that the root usually contains no pith or medullary sheath. Sometimes, however, both are present, as in the Walnut and Horse-Chestnut. The root also wants for the most part the liber and cambium-layers as they are seen in exogenous stems.

Both the axial and the adventitious roots of Exogens ranch by a bifurcation of their growing point; the advenitious roots of Monocotyledons branch by producing new dventitious roots.

From their Root System, meaning thereby the whole ollection of roots on the plant, originating by developent of the radicle outside the bark, Exogens were called y Richard *Exorhizæ.* The younger portions of the roots f Exogens are very often covered with hairs, which sually consist of simple elongated epidermal cells. These airs are sometimes called *Fibrillæ*, but must be disinguished from the smaller rootlets, to which some have iven the same name.

The differences between the stem and the root in a)icotyledonous plant may be roughly enumerated thus:—

STEM.	ROOT.
)eveloped from the plumule.	Developed from radicle.
}rows upwards towards the light.	Grows downwards from light.
Ias a pith, medullary sheath, liber, and cambium.	Wants all of these except in a few plants.
Covered by an epidermis, with stomata.	Covered by an epiblema, without stomata.
)evelopes leaves and leaf-buds.	Generally wants both.

AERIAL ROOTS.—There are two groups of plants posessing peculiar roots which deserve attention: these are ERIAL PLANTS OR EPIPHYTES and PARASITES. The former roup of plants do not send their roots into the ground t all, but allow them to hang suspended in the air: in hese cases the roots have an epidermis and stomata, like tems (Fig. 10). Some orchids have their aerial rootlets overed by a layer of thin-walled cells, sometimes called he *Velamen Radicum.*

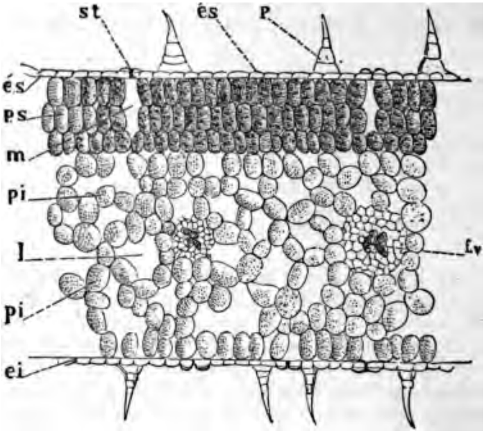
PARASITIC ROOTS.—Some plants, when developed from he seed in favourable situations, send their radicles into he rind of such other plants as may be in contact with hem, and thus become grafted on the supporting plant. n certain cases, as in the Mistletoe, the root is not furher developed. In other instances, there is a sort of stem roduced below the rind of the nurse-plant, as in Rafflesia (Fig. 310).

LEAVES AND THEIR MODIFICATIONS.

All leaf-like appendages of the stem have the same general structure. They consist of a skeleton of fibro-vascular bundles, supporting one or more layers of loose cellular tissue. They are covered by an epidermis, and are usually abundantly provided with stomata.

Leaves originate as small masses of undifferentiate tissue below the level of the growing point of the plant and this is always on the outside, never from the inside of the growing stem, as sometimes happens in the cas

FIG. 287.

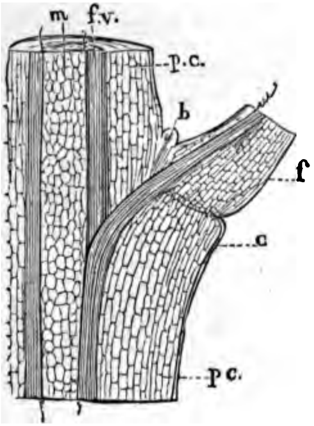


Vertical section of the leaf of the Melon. *st*. Stomata; *p*, Papillæ or hairs; *e s*, Superior epidermis; *p s*. Denser portion of parenchyma; *l* & *m*, Intercellular passages; *f v*, Fibro-vascular bundles; *p i*, Looser parenchyma; *e i*, Inferior epidermis.

of roots. Histologically, the leaf is similar to the ste and no definite boundary can be found between the tw inasmuch as both arise from the yet undifferentiated c lular tissue. The fibro-vascular bundles of which t skeleton of the leaf consists are best seen on the und surface of the leaf. Towards their termination they oft consist of prosenchymatous cells only. The parenchy leaf is very loose, and contains large intercellular , which communicate with the outer air through tomata. These stomata are usually most numerous e under surface of the leaf. In submerged plants re usually absent, as they also are on the under es of floating leaves.

ves at first grow like shoots at their free extremities, a rule their growth is distinctly limited. There is an interstitial growth for some time, but that is nated by a permanent differentiation of the cells of

FIG. 288.



rtical section of a petiole where it joins the stem. *m*, Pith; Fibro-vascular bundles; *p c*, Cortical parenchyma; *b*, Bud; icatrix forming; *c*, Pulvinus.

rowing organ. Leaf structures may assume forms nlike ordinary leaves.

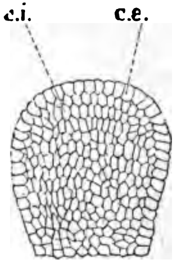
hardness of leaves depends chiefly upon hardening hickening of their epidermal cells, as in the Holly, All the cells of the leaf usually contain chlorophyll.

ACTS, SEPALS, and PETALS are constructed on the same as leaves, but want many of the fibro-vascular es. What fibro-vascular bundles they do contain consist of *spiral* vessels. The cells of the coloured parts contain not *solid grains of chlorophyll*, but *various coloured fluids*, called *Chromule*. The arrangement of the veins in the sepals and petals usually agrees with that of the leaves. Stomata are rarer on sepals, and especially petals, than on the leaves; when seen they are most frequently on the lower or outer surface. In their earliest stage, sepals and petals consist of little projections of cellular tissue, free and of equal size, whatever they may afterwards become. Sometimes the stamens appear before the petals, though nearer the organic apex of the plant.

Stamens and Pollen.

Stamens or staminal leaves consist like other leaf-structures of fibro-vascular bundles, of parenchyma, and epidermis, only the fibro-vascular bundle is reduced in most cases to the condition of a few spiral vessels, and a part of the parenchyma is modified into what is termed *pollen*. This is the specific product of the stamen.

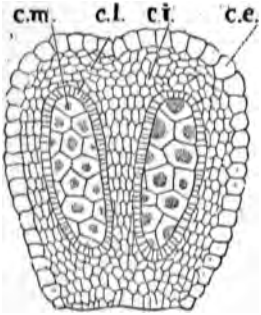
Fig. 289.



Vertical section of young anther. *c e*, External cellular tissue becoming epidermis; *e i*, Internal cellular tissue, part of which goes to form the pollen.

Stamens originate like leaves as small cellular protuberances from the growing axis of the plant usually after the appearance of the corolla, but very often they grow much faster. The anther lobes appear first, after *them* the filament which grows mainly by intercellular growth. The young stamens consist entirely of undifferentiated cellular tissue, the outer cells which are to form idermis differing but slightly (Fig. 289) from the nternal. By-and-by in the upper part of these is, that is in the anthers, the central cells begin to . Four sets of cells are formed by a stronger growth wer division. These cells, which are larger than the are grouped in two divisions on either side of the tive and constitute the primary mother cells of the They are surrounded by a small cell growth, ıermost layer of which forms a kind of epidermis inner covering of the pollen sac (Fig. 290).

FIG. 290.

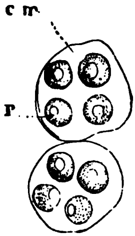


tical section of an anther lobe (Melon). *c e*, Exothecium; ellular tissue of anther; *c l*, Endothecium; *c m*, Mother f the pollen.

large mother cells generally develope a thicker coat sual, and may become quite separate. Their pro- n is rounded off within them, and their nucleus ears. Ultimately four fresh nuclei make their ap- ice, and the protoplasm divides—with ingrowth of llulose coat of the cell—into four separate masses 91) united into one tetrahedron. Each of the con- protoplasmic masses forms for itself a new cell vhich afterwards becomes thick and splits into ıyers, the *extine* and *intine*, or outer and inner ıg of the pollen grain (Fig. 292). The extine is covered with knobs or spines, and often leaves uncovered or with thinned walls. It becomes *converted into cuticle*; the intine is of cellulose.

From it is developed the pollen tube. By the destruction of the walls of the mother cell, the pollen grains are set at liberty and soon fill up the space devoted to them. Their contents consist of a coarse protoplasm with some starch and oil. It is termed the *Fovilla*. The extine is usually covered with an oily viscid substance which makes it the more readily adhere to any object with which it is brought in contact.

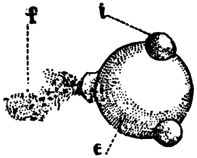
FIG. 291.



Mother cells and pollen grains. *c m*, Mother cell. P, Pollen grains.

Towards the time when the pollen is ripe, the walls of the pollen sacs undergo change. The external coating of the anther or epidermis (termed Exothecium) remains smooth, but the cells of the internal layer, or Endothecium, if the anther is preparing to burst, undergo change. When the pollen is ripe the anther walls rupture, and the pollen escapes.

FIG. 292.



Pollen grain bursting. *e*, Extine; *i*, Intine; *f*, Fovilla.

The anther cells, originally four in number, are before this time usually reduced to two or even one by the rupture of their cell walls. Occasionally too, the walls of the mother cells do not allow of the perfect escape of the pollen grains which are thus retained in bundles termed *pollinia*. Such are common in the Orchid family. In Asclepiads the pollen grains are bound together by a waxy substance.

CARPELS.

All *carpellary* leaves, like ordinary leaves, are composed of cellular tissue, or parenchyma, contain fibro-vascular bundles, and are lined without and within with epidermis. In the style, the fibro-vascular bundles occupy the periphery, not the centre. The centre of the style is occupied by a spongy tissue or loose parenchyma, called the *conducting tissue*. At its summit the style expands into the stigma, which is not covered by an epidermis.

From the fibro-vascular part of the placenta, a thin bundle of spiral vessels passes to the ovule. This is called the *Chalaza*. The ovule has already been described, and the process of fecundation will be so at a subsequent stage.

PART II.

SECTION II.

THE PHYSIOLOGY OF PLANTS.

CHAPTER I.

CHEMICAL CONSTITUENTS OF PLANTS AND THEIR SOURCES.

To enable one to study the functions, that is the various processes carried on in living beings, and the changes which different substances undergo to fit them for nourishing or reproducing the plant, a knowledge of chemistry is absolutely necessary. Nor is the subject of vegetable chemistry of importance from a theoretical point of view only, for it forms a fitting introduction to the far more complex study of animal chemistry. Moreover, it supplies the agriculturist with information as to what crop will best suit a particular soil, or *vice versâ,* and what manure will be best suited to a given soil or crop.

The constituents of plants may be divided into two grand groups, *Inorganic* and *Organic*—the *former* common to them with all the other kingdoms of nature as they are called, the *latter* peculiar to them with animals, or to themselves alone.

As a rule, the Inorganic constituents of plants are *binary* compounds, whilst the Organic consist of *ternary* or *quaternary* combinations of chemical elements, though this rule is far from being absolute. Inorganic compounds may be produced *artificially*, whilst organic bodies require the *intervention of life* for their formation. Organic compounds may be destroyed by a high temperature and are liable to putrefaction. Inorganic sub-

;ances are incombustible, though they may be altered y heat, and may even be formed by heat, They are not able to putrefaction.

A. INORGANIC BODIES FOUND IN PLANTS.

The more important of the inorganic constituents of lants are as follows:—

SULPHUR (S), *as Sulphates combined with various bases.*
PHOSPHORUS (P), *as Phosphates also in combination ith various bases.*
SILICON (Si), *as Silica, or as Silicates.*
POTASSIUM (K), *in combination with acids.*
SODIUM (Na), *in combination with acids.*
MAGNESIUM (Mg), *in combination with acids.*
CALCIUM (Ca), *in combination with acids.*
CHLORINE (Cl), *in combination as Chlorides.*
IODINE (I), *in combination as Iodides.*

IRON and MANGANESE also exist in small quantities in ıme plants.

BROMINE and FLUORINE, as Bromides and Fluorides, ist in very small proportions in a few plants.

ALUMINUM, in the form of alum, has been detected as a nstituent, but apparently an accidental one, of one or ro vegetables only.

The inorganic constituents, though small in quantity as mpared with the organic, are still of considerable im- ırtance in the vegetable economy. Both sulphur and ıosphorus are essential constituents of albuminous com- ıunds.

All plants do not contain the same chemical com- ıunds, nor does the same plant when grown in different tuations yield ashes of the same composition. Thus lica is present in large quantity in the stems of Grasses, hile in leguminous plants it is very scanty. Phosphates cur chiefly in seeds, while they may be almost entirely ranting in the stems of the same plants. Lime abounds the stems of leguminous plants, while in those of 'asses it is very deficient, and there is more in the bark an in the wood of trees, being replaced in the latter tuation by soda and potash, more especially the latter. ants which usually contain soda when grown near the a, may yield potash when grown inland. Lime is abundant in most plants; as phosphate of lime it occurs in the seeds of cereals, as sulphate and carbonate it is found in Characeæ, and as oxalate in the form of raphides in many plants. Silica occurs chiefly in the Grasses, Equisetaceæ, and Diatomaceæ. Iodine is found in marine plants only.

B. Organic Constituents.

The organic constituents, or the combustible part of plants, consist of Carbon, Hydrogen, and Oxygen, with Nitrogen combined in various proportions.

Vegetable organic compounds are accordingly subdivided into two groups—viz., the Azotized or Nitrogenous, and the Non-Azotized or Non-Nitrogenous, characterised by the presence or absence of Nitrogen.

Carbon.—Of all the elements found in plants, *Carbon* is by far the most constant and the most abundant. Combined with Oxygen in the form of Carbonic Acid, it exists in the atmosphere, whence it is abstracted by living plants, the Carbon being fixed by them, and the Oxygen being set free. When wood decays or burns the process is reversed, and the Carbon becomes converted into Carbonic Acid. By the decay of plants what is called *vegetable mould* is produced, which, though it cannot itself be absorbed by plants, yet acts as a medium for the abstraction of substances from the atmosphere, which can afterwards be absorbed by the plant. Of course such salts as the mould contains ready formed may become immediately available for the plant's use.

Oxygen is another important constituent of vegetables, but though it makes a large bulk in the estimation of their constituents, it exists mostly in the condition of Carbonic Acid and water.

Hydrogen also exists chiefly as water, though it occurs in other combinations, as with Carbon in the form of fats, oils, &c.

The substances which in addition to Carbon, Hydrogen, and Oxygen, contain Nitrogen, are termed Azotized. They usually contain besides these, certain proportions of Sulphur and Phosphorus. The type of this class of constituents is Albumen.

The next in importance is vegetable *fibrin*, seen in the *gluten* of *wheat*, and vegetable *casein*, represented by the *Legumen* of pulse. The source of the Nitrogen in is supposed to be Ammonia, which, in combination rtain acids, is chiefly absorbed by the roots.

maintain, though incorrectly, that plants have ver of abstracting Nitrogen directly from the at-re; others, with greater reason, hold that the urce of nitrogen is the nitrates and ammoniacal nds contained in the soil. Nitrogenized com- are found wherever protoplasm exists, but they are specially abundant in the seed, and in the outer than the inner portion of the seed. Hence it is own bread, or bread containing the outer part of in of wheat, has really more flesh-forming mate- it than the pure white bread, which consists entirely of starch.

Soils.

ig, that all plants do not abstract the same sub- from the soil, and seeing also that the constitu- soils varies, it follows that some plants will be suited to one kind of soil than others would be. atmospheric food is tolerably uniformly dis- d, and not so much under control as the earth is, iculturist directs his attention solely to the latter. ost important constituents of soils are *sand* or *clay* or *silicate of alumina; lime*, chiefly as *car-*; and *vegetable mould.* These exist in varying tions, and it is the business of the farmer to select op which will best suit his soil; or to supply any soil with the elements it most wants. This he iefly by means of manures, but also by mixing one soil with another.

it is termed a *loamy* soil is a mixture of sand, clay, nd vegetable mould in varying proportions, and is st suited for all kinds of crops. Should any one f crop be repeatedly grown on any soil, however it must ultimately abstract all the matter avail- r this particular kind of crop from this soil, leaving ren, though only with reference to this one crop. l another kind of crop be substituted its growth be quite vigorous and the result highly satis- y. On this principle is founded what is called the of the *Rotation of Crops.*

eals *chiefly abstract* silica; beans and clover lime;

soluble and available by it. Farm-yard manur all the ingredients wanted in a soil, and ac Special manures supply only one or two substa as these may act only as solvents, they are mo exhausted. The most valuable ingredients i manures are ammonia and phosphates.

CHAPTER II.

MOLECULAR FORCES AND PLANT LIFE.

LANTS, like all other bodies, are composed of certain nolecules variously aggregated together, and subject to he action of various laws. As in all organized beings, vater holds an important place in the constitution of lants. Addition of water to their substance causes them o swell, abstraction of it causes them to shrink. Hence, s evaporation mainly, though not entirely, depends on emperature, this, too, exercises an important influence on lant life. Excess of evaporation may easily lead to conditions incompatible with life.

The series of phenomena associated with these changes ead to the belief that plants are composed, as already aid, of isolated molecules, and that the interstices etween these are everywhere permeated by fluid. These nolecules, like all others, are influenced by these various orces: *Cohesion within themselves*, *Attraction for each ther*, and *Attraction for water*. Absorbed water may ot be diffused equally in every direction, but only in ertain layers or strata running in given directions, so hat variation in its quantity at various spots may cause hange of shape more in one direction than in another.

It is by means of these currents of fluid that nutrition s accomplished. The nutrient fluids penetrate between he molecules and either add to their size, or lay down thers between them. This solidification of certain of he particles in the nutrient fluid leads to an alteration f its specific gravity, or rather of its osmotic equilibrium, nd so currents are set up which from opposite causes, ay from solution of these particles, may be reversed.

Bodies which have an extreme attraction for water are ometimes termed *Hygroscopic*—a dried portion of the hallus of Laminaria furnishes a good instance. The uids which thus permeate the plant and nourish it have his important characteristic, that the new substances hey carry are not identical with those they go to replace. Thus starch grains are not nourished by water containing articles of *starch, but* by some substances capable of yielding the elements of starch. This process of construction is of course a chemical process, and accordingly whilst it is going on all parts are in a state of instability, an instability which is more or less constant through the life of the plant, for the addition of fresh matter also implies in certain cases the removal of that which is effete. To effect this there must be a continual flow of water and of air within the plant. The movements of the water are mainly effected by the necessities of growing cells, partly by evaporation. The movements of gases are chiefly carried on in accordance with the laws of the interchange of gases.

CHAPTER III.

PHYSIOLOGY OF THE ORGANS OF NUTRITION, OR VEGETATION.

I. *The Root.*

THE chief functions fulfilled by the roots are—1st, Fixing the plant if it penetrate the soil, or become attached to any stationary body; 2nd, The absorption of nourishment already in a fluid state; and 3rd, To act as a reservoir of nourishment.

Absorption.—The power of absorbing nourishment is possessed by the root, more especially in its youngest parts where the epidermal cells are thin-walled, and in the ibrils which proceed from the older portions. After a ime the outer covering makes way for a corky structure which more or less effectually resists the permeation of fluids.

As plants are fixed to one spot, and cannot move about n quest of their food, some compensating process must be at work to enable them to survive, when the soil immediately surrounding their bases is exhausted. This is ffected by the spreading of the roots themselves, and this hey always tend to do in the direction in which the upply of nourishment is most abundant. As a rule, the oots extend as far as the branches spread, sometimes ven farther; though the roots of some plants tend rather o spread, whilst those of others tend to penetrate deeply nto the soil. When, therefore, a plant is watered, it hould not be immediately at the base of the stem, but at ome distance from it; and when a tree is to be transplanted, the earth should be cut at such a distance from he stem as to secure the integrity of the younger fibres, eeing that they are the parts which are most necessary or the nourishment of the plant. Hence, also, it is better o transplant in autumn or in early spring, when absorpion is not at all active, so that the plant has a little time o recover itself before being called upon for the more ctive performance of its functions.

The *means by which* absorption is effected is by the process of osmose, now fairly well understood. Accordingly what substances are taken up must be fluid. No matter, therefore, however much nutritive material a soil may contain, if it be not in a soluble condition the ground will be barren. Nor are all substances, though equally soluble, equally absorbed, for plants appear to have to a certain extent the power of selecting the substances most suitable to their wants. This is seen when the roots of a plant are placed in a fluid containing various salts in solution, for it will be found that one salt is taken up in much larger quantity than another. This selective power, however, only exists as long as the roots are entire, for, should they be cut across, the salts will be absorbed in the same proportions.

Some roots, more especially those that do not spread, serve as *reservoirs of nourishment*, usually laid up in autumn for use during the following spring and summer. The nourishment thus accumulated is chiefly starch, as is seen in Dahlias and Orchids.

Roots which do not penetrate the soil may abstract nourishment from the air, as in many Orchids or from other plants, as the Dodder, Fungi, &c.

When roots have long drawn their nourishment from a given spot, they exhaust the soil of certain substances, leaving certain others abundant. A very good illustration of this point is to be had in the case of the Fairy Rings, seen in old pastures. These rings are produced by a peculiar fungus, which completely exhausts the soil behind it of the products necessary for its own growth, and is therefore compelled to develop in a centrifugal manner. The fungi abstract nearly all the nourishment from the soil on which they grow, which is therefore barren of grass; when, however, they decay, they restore the needful constituents to the soil, and the grass springs up more luxuriantly than ever. Should one ring meet another they will both break, as the soil over which either has passed is incapable of supporting the other.

II. *The Stem.*

The principal functions performed by the stem are—1st, The support of the other organs of nutrition, and the organs of reproduction; 2nd, The conveyance upward of the crude sap and downwards of the elaborated juice;

and, 3rd, The reception and storing away of the secretions peculiar to the plant.

As the means of elevating the leaves and other organs into the air, the stem must attain a greater or less altitude. Sometimes it only reaches the surface of the soil, while at others it rises to the height of 200 or 300 feet above the level of the ground, attaining also in some cases a proportional thickness.

With regard to the functions of the various constituents of the stem, the *pith* seems originally to supply nourishment to the other parts of the plant, for at an early period its constituent cells contain protoplasm. These cell contents soon disappear, and the cells become empty, and their walls colourless. After a time, however, they may again become reservoirs of nourishment, laid up for the future use of the plant. The layer of spiral vessels immediately surrounding the pith, and sometimes called the *medullary sheath*, appears, like other vessels of the kind, to contain air on ordinary occasions, but fluid when there is a greater supply of it than usual.

The Wood.—In its young state the woody tissue serves as the chief means of conveying the crude sap from the root to be elaborated by the leaves; but in course of time the older prosenchymatous cells are filled up with secondary deposits, and become impermeable by fluids, though before this has taken place the new wood which has been produced serves as the medium of transmission. These different layers of woody tissue are distinguished as the *Duramen* and *Alburnum.* The *medullary rays* which connect the bark with the pith also occasionally serve for the transmission of the sap.

The Bark.—The grand function fulfilled by the bark is the protection of the internal organs, but so long as it remains green it will act on the juices in the same way as the leaves and other green parts of the plant. The internal part of the bark is the medium through which the elaborated sap is transmitted downwards from the leaves. It also serves as a reservoir for secretions of importance, as alkaloids, resins, gummy matters, &c.

With regard to the mode in which stems are formed, two opinions prevail. Du Petit Thouars and Gaudichaud looked upon each plant as a compound individual, made up of a number of what they called *Phytons*. The former considered *each* bud as a phyton, the latter held that each leaf was one. As in the embryo two parts are seen, one part ascending to become the stem, another descending to become the root, so, said they, each phyton consists of two parts, an ascending and a descending, but as the descending part or root cannot reach the ground immediately, it tries to do so by passing straight down on the outside of the wood and so inside the bark, and constitutes the woody fibres which go to increase the stems, as already described. This view has been maintained more especially with regard to Palms, and those trees which, like the Pandanus, produce aerial roots. Wood, however, would seem to be produced not from above downwards, but rather, more especially in the case of Dicotyledons, laterally, in the manner already described.

III. *Leaves.*

The chief functions fulfilled by the leaves are—1st, The absorption of necessary fluid; 2nd, The exhalation of superfluous fluid; 3rd, The absorption and exhalation of gases; and 4th, The elaboration of the sap of the plant and the formation of peculiar secretions.

1. *Absorption of Fluid.*—The power of absorbing fluid possessed by leaves depends on the thickness of the cuticular or corky changes in their epidermis, and the number of stomata in it. Accordingly, leaves can, as a rule, absorb most readily by their under surfaces where the cuticle and epidermis are thinnest, and the stomata are most numerous. Another powerful agent in retarding absorption is the presence of fatty or resinous matters in the superficial cells, and as these matters are most abundant in old epidermis, absorption does not take place so readily in the old as in the young tissues. When these peculiar matters are removed by any means, absorption goes on much more rapidly. When the leaves absorb moisture it is apt to pass into their spiral vessels, and displace the air which they usually contain.

2. *The Transpiration or Exhalation of Fluid*, which takes place for the thickening of the vegetable juices, will be regulated by much the same laws as absorption, taking place chiefly by the stomata and in those parts which have a thin epidermis, destitute of resinous matters, especially along the ribs. Another important regulating agent is the presence or absence of moisture in the at-

mosphere, for of course there will be a greater tendency to exhale fluid in a dry, than in a moist atmosphere. Nevertheless, some succulent plants can manage to live in very arid situations, a thick epidermis and few stomata preventing the transpiration of what fluid they can obtain from the soil. One most important influence brought to bear on transpiration seems, however, to be *light;* the brighter the light to which a plant is exposed the greater is the amount of its transpiration. The *light-giving* rays of the solar spectrum seem to promote this more than the *chemical* rays. Plants grown in the dark are apt to become dropsical from the accumulation of fluid in their tissues, as the roots go on absorbing, though the leaves be giving out but little fluid. With the amount of light the thickness of the epidermis also varies so as to keep up, as much as possible, a proper equilibrium. The fluid exhaled has a most important bearing on the climate of a country, for where trees are very numerous the climate is moist, while the clearing away of large tracts of forest has brought aridity and sterility in its train. Some trees, however, seem to have the power of drying the soil, and thus rendering marshy land inhabitable. The best xample of this is the action of Eucalyptus globulus.

In some plants a very great amount of fluid is absorbed y the roots, and secreted almost without change. In a w cases, as in the Pitcher plant, it is preserved in recep- cles for the purpose, but this fluid is not exactly the me as that exhaled by the leaves, seeing that it contains rious saline and organic matters, whereas the other is re water.

. *The Absorption and Exhalation of Gases, or Veget-* *Respiration.*—This is chiefly carried on by the es, the gases acted on being chiefly *Carbonic Acid* and *gen*, with, according to some, a little *Nitrogen.* The conflicting notions on the subject have prevailed, but ollowing is the correct view. Leaves and other green of the plant, when exposed to the light, absorb nic acid. They fix carbon and discharge the oxygen. lants do not possess this power to the same extent, plants being especially useful in forming oxygen. h transpiration so with respiration, the illuminating the solar spectrum appear to be much more power- n the chemical in promoting this process.

ts *absorb carbonic* acid, but they also absorb oxygen, and this is usually masked by the greater amount of oxygen exhaled. The green parts of plants in point of fact absorb carbon dioxide and fix the carbon, whilst the coloured parts reverse the process, absorbing oxygen and forming carbonic acid just as animals do. The action of vegetables on the atmosphere is thus in the main antagonistic to that of animals. No better instance of this can be cited than the aquarium, where animal life must be complemented by vegetable life, so that the balance in the production of oxygen and carbonic acid may be kept up and both animals and vegetables be able to flourish.

The *Elaboration of the plant sap*, and the formation of its various secretions and excretions, are effected in the leaves by the processes just described. Should by any means the leaves be destroyed or diseased, the crude sap does not undergo the necessary change known as *Assimilation*, and is therefore incapable of nourishing the plant, or of forming wood or colouring matters. The same effect may be produced by depriving the leaves of light, or supplying it in insufficient quantities, as is done in blanching celery. Owing to the absence of this necessary stimulus, the woody tissue is not properly developed, and thin-walled cells take the place of the thickened fibres, rendering the plant more succulent and tender. Potatoes grown in a shady spot want starch and are very watery. Trees grown in a thick plantation are comparatively feeble and produce bad timber.

The effect of gases on leaves or on vegetation generally is elsewhere described. Some gases, as hydrogen, nitrogen, oxygen, and nitrous oxide, appear to be innocuous, or at least act prejudicially only in as far as they cannot supply the carbonic acid necessary for the welfare of plants. Even carbonic acid in too great quantity becomes prejudicial, though some of the lower plants survive for a time in an atmosphere containing a very large proportion of it. Certain gases, as hydrochloric and sulphurous acids, are excessively destructive, proving injurious in quantities far too small to be detected by any of the senses. They begin by attacking the tips of the leaves, and afterwards seize upon the stalks, shrivelling them and turning them greyish. Other gases, as sulphuretted hydrogen, cyanogen, carbonic oxide, and carburetted hydrogen, though equally destructive, act in a different manner, producing flaccidity and death without any alteration of colour. As such gases abound in the atmosphere of all large cities, delicate plants will not thrive there. To overcome this difficulty cases are now commonly used fitting closely on to a stand which contains soil, and by this means people are able to cultivate plants in the smokiest parts of London. The plants are well watered when they are planted, and the glass prevents its vapour from escaping when exhaled, so that it is condensed on the glass and reabsorbed by the plants. The glass cover keeps off all dust and smoke, while the air within the case is slowly changed by the narrow passage existing between the glass and the box, for though closely fitting it is not hermetically sealed. By means of these cases young plants have been conveyed from one country to another, as in the case of the Cinchona plants from South America to India and Java.

Coloration of Leaves.—The green colour of leaves depends on the formation of chlorophyll, as formerly explained, and as light is necessary for the formation of this substance, plants kept in the dark are always pale in hue. A short exposure of blanched plants to the rays of the sun, or even to diffuse daylight, suffices for the formation of the green colouring matter; this, however, may be made to disappear again by replacing them in the dark.

In some plants the process of blanching is attended by the formation of *asparagin*. The changes of colours seen to take place in autumn are owing, in part at least, to the oxidation of the chlorophyll. Variegation of leaves is, in some instances, produced by cells containing air below the cuticle of the leaf; in others, by alterations in the colouring matter.

Defoliation, or Fall of the Leaf.—At certain periods the leaves which have fulfilled their term of office fall off, and make way for young ones. When the leaves are jointed at their attachment to the stem, they usually give way there; but in those cases where there is no articulation, as in many Monocotyledons, they wither down, and fall bit by bit. Most of our trees shed their leaves in autumn, but on some they are persistent for a considerable length of time after. In warm climates they usually fall during the dry season. When leaves fall off immediately on the expansion of the leaf-bud they are said to be *caducous; when in* autumn, *deciduous*; when after the lapse of a longer period, *persistent*. Plants having persistent leaves, lasting over winter, are called *evergreens*.

As to the fall of the leaf, the cause most frequently assigned is blocking up the cells with inorganic matters deposited from the viscid sap, or relative changes in the amount of their cell sap. A small groove (the joint) is seen at the point where the leaf is attached to the stem (Fig. 288), which gradually deepens till the stalk is almost cut through, and the slightest impulse is sufficient to break it off. The form of the cicatrix left behind is important, as furnishing characters in fossil plants.

CHAPTER IV.

CIRCULATION OF THE SAP.

rly spring, when plants begin to recover from their
r lethargy, the roots, which so often contain starchy
er, partake in the renewed activity. By the action
e vegetable fibrin or diastase contained in them, the
h is converted first into dextrin, then into sugar.
r being soluble, though starch is not, the density of
ell contents is increased, and a process of endosmose
up, by which the fluids in the soil pass into the
ior of the plant. Simultaneously with this in-
ed activity of the root there is a fresh accession of
r to the upper part of the plant. Exhalation be-
s more active, so that the contents of the cells in
part acquire a greater density than in those below,
g to which there is a tendency of the sap to pass
rds. In spring, when the sap is abundant, and fills
e vessels, capillary attraction may have something
with the ascent of fluid, for though capillary vessels
ever of themselves produce a through current, yet
will always raise fluids to a certain height, and if
fluids be continually removed from this level by
ration, or by any other means, an upward current
be the result. By exhalation the fluid in the spiral
ls is got rid of, and its place taken by air, but in
climbing plants its presence in those vessels is per-
nt. Gases, chiefly carbonic acid and oxygen, are
ined in the ascending sap.

to the route pursued by the ascending and the
nding sap, various opinions prevail. In cellular
s, as Fungi, no definite route is adopted, but in
gens the ascending sap appears to follow the route
e fibro-vascular bundles, though not contained in
piral and scalariform vessels of which these bundles
artially composed. In Monocotyledons the sap also
ars to follow the course of the individual bundles in
ted currents, and as the bundles are curved, the sap
ars to pass upwards in a similar direction. The
channels *of ascent* are the elongated cells surround-

ing the spiral vessels. Sap for the nourishment of the plant must pass through all kinds of tissues.

The chief channels by which the crude sap ascends in Dicotyledons are the young fibro-vascular bundles.

During early spring some plants, as the Vine, are very liable to what is called bleeding, that is, to the escape of the vegetable sap. After the leaves are fully formed, and the regular currents are properly established, this does not occur. When the sap reaches the leaves it is acted upon by the light and air in the manner already described, and the elaborated sap begins to descend, but as to the exact mode of descent various opinions are entertained. All are agreed that the chief agent of downward transmission is the bark, and laticiferous vessels. From the bark elaborated juices are also conveyed inwards by means of the medullary rays. As to the cause of the descent of the sap, nothing is really known, though it is certain that in Dicotyledons a downward current really takes place. A practical application of this knowledge is seen in the "ringing" of fruit trees; *i.e.*, depriving them of a circular slip of bark, which prevents the descent of the sap, and thereby favours the production of fruit on the part above.

The means adopted for discovering the rapidity of the ascent of the sap are by causing the plant to take up a substance which would be easily recognised by some chemical reaction, as ferrocyanide of potassium, which with a persalt of iron forms Prussian blue, and taking portions of the sap from the trunk at different heights, noting at what time it first gives a reaction. Heat, light, and moisture appear to be the most powerful agents in favouring the circulation of sap in plants. In some plants, the force of the ascending sap is very great. In one experiment, Hales found it capable of sustaining a column of mercury thirty-eight inches high in a curved glass tube.

CHAPTER V.

PHYSIOLOGY OF THE FLORAL ENVELOPES.

HE green parts of the flower have exactly the same unctions as leaves, with, in addition, that of protecting ie tender organs internal to them. They absorb car-onic acid and give out oxygen, but the coloured portions osorb oxygen and evolve carbonic acid. By this means ie starch, so often present in the receptacle of the owers, is oxidized and converted into sugar, which fords nourishment for the essential organs. This pro-ss is, therefore, more marked in the case of perfect than imperfect or neutral flowers.

Evolution of Heat.—As a natural consequence of this idation flowers evolve heat, but as the process is gra-ual, and the exposed surfaces large, it passes off into the urrounding atmosphere in an imperceptible manner. There, however, the heat is confined, as by the spathes the Arum family, the temperature has been observed rise from 15° to 50° Fahr. above that of the air sur-unding the plant. The evolution of heat is increased y placing the plant in oxygen gas.

As to the age at which plants produce flowers, some se from the seed, produce flowers, and die in a single eason, hence termed annuals (⊙); others only increase size during the first year, but produce flowers, and ien decay during the second, and are called *biennials* (♂); hile a third kind continues to produce flowers for several ears in succession, and are termed *perennials* (♃). Some lants, more especially Agaves, do not flower till after iany years, and, apparently exhausted by the process, ie immediately after the fruit is matured. Different owers appear at different seasons, and expanding with olerable regularity, constitute a sort of "Floral Ca-endar."

Not only is there considerable variety as to the period t which flowers first make their appearance, but in those hich close up during the night, there are also variations s to the period of the day at which they expand again. ome open *early in the* morning, others at midday, and others still in the evening. The Compositæ are remarkable for their tendency to open and shut. Linnæus observed this phenomenon, and selected plants enough to constitute a *floral clock*. Some plants reverse the ordinary current of events, and remain closed during the day, opening at night only. As to the cause of these movements, light and heat are the principal agents.

The Colour of Flowers.

The part of the flower most frequently coloured is the corolla, but occasionally the calyx and bracts are so also. The colour of the flower is extremely variable, and is, therefore, of little use as a specific character, except among the lower plants, as Fungi and Algæ. Various attempts have been made to classify the shades of colour observed in plants, and thus render them more useful in systematic botany.

Cultivation has a very powerful effect in modifying the colours of flowers, but all the changes take place within certain definite limits. According to De Candolle, there are two series—a Yellow, or *Xanthic*, and a Blue, or *Cyanic*; these merge into each other imperceptibly, but if a plant belong to one series, say yellow, it can never be made to turn blue, and *vice-versâ*. Thus a blue Rose and a yellow Geranium are unknown in Horticulture. This rule is not absolute, still it is of very general application.

The Odour of Flowers.

The smell of flowers is due to some volatile oil, or a resin dissolved in oil, and is usually given out most readily on exposure to sunlight, though in some cases, on the other hand, it is only developed during the night. In the latter class the evolution of the odour is often intermittent. It often happens that the least showy flowers are most aromatic. Flowers of an orange or brown hue often evolve a fœtid odour.

CHAPTER VI.

FUNCTIONS OF THE REPRODUCTIVE ORGANS.

FROM a very early period the existence of distinct sexual organs in plants has been known, and the knowledge practically employed, for the application of clusters of male flowers to female flowers was had recourse to in Egypt many centuries ago to insure the fertility of the Date Palm. At that time small flies were supposed to be the active agents in effecting fecundation. Up to the time of Grew nothing was known with regard to the relative functions of stamens and pistils, nor was it till the time of Linnæus that the subject received the attention it deserved, and it was not till a much later date that the exact relation of the pollen grains to the ovule and embryo was made out.

Some female flowers seem occasionally to produce fruit without the agency of pollen, but in most cases such production is only apparent, fecundation having been effected by pollen carried from a distance. Occasionally it arises from flowers, which usually produce pistils only, giving rise to stamens. Some instances of real *Parthenogenesis* occur, but they are very few, one of the most noticeable being the case of the Cœlobogyne, a Euphorbiaceous plant.

To insure the application of the pollen to the stigma, the relative lengths of the stamens and style vary with the character of the flower whether erect or pendulous; the stamens being longer than the style in the former kind, but shorter in the latter. In some plants, as the Nettle, the anthers burst with considerable force, scattering the pollen in every direction. Insects are most important agents in the fecundation of plants; they are attracted to the flower either by its peculiar shape, as in some Orchids, or by the presence of sugar at the base of the petals, and in searching for it rub off some pollen which they convey to the flower they next visit.

Pollen grains must be kept from contact with water, to prevent their premature rupture. This is effected by the closure or inversion of the flower during rain, and in most water-plants by the elevation of the blossom above water. Pollen, when long kept, becomes incapable of fecundating the ovule, but the period at which it becomes inert is very various. In some plants—as the Tobacco plant—it becomes useless in forty-eight hours, while in other cases, as the Date Palm, pollen kept for eighteen years has been successfully used for the production of fruit.

In some of the Coniferæ enormous quantities of pollen are produced, and being of a yellow colour, has given rise to the so-called *sulphur showers*. The great abundance of pollen in these and other instances is connected with the monœcious or diœcious character of their reproductive organs, and the consequent difficulty of conveying enough pollen to insure fertilization. The amount of pollen required to fertilize a flower completely will vary with the number of ovules contained in the ovary, but allowance must always be made for some of the pollen grains not coming in contact with the ovule, even though applied to the stigma. In most cases the pollen produced by a single anther is quite sufficient to fertilize all the ovules in the ovary, so that when more than one stamen is present it is only to insure the application of a sufficient quantity of pollen to the stigma.

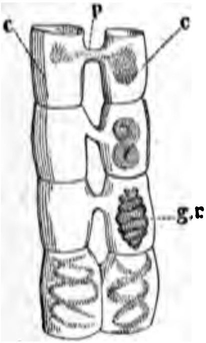
I. REPRODUCTION AMONG CRYPTOGAMS.

The manner in which Algæ are reproduced is, though at first sight it may seem strange, better known than that in which it takes place in the higher divisions of the vegetable kingdom. The reason is that here the process is to be found at its simplest, and that its study throws light on the more complex problems affecting reproduction in the higher groups of plants. Reproduction without any distinction of sex occurs in all Algæ, but in many true sexual reproduction occurs. In a certain number we even find what is called alternation of generations—that is, when a plant gives rise to a new growth, which is unlike itself, but when the new growth developes a being similar to its own parent. This may be formulated otherwise. When the parent gives rise to a son unlike himself, but like the grandfather, whilst the son gives rise to one unlike himself, but like his father. Among Algæ this commonly takes the form of sexual generation in one generation and asexual in the next.

In asexual reproduction the spores may be either motionless or mobile. The moving or swarm spores in any case soon lose their power of motion: they become fixed, and begin to sprout.

In sexual reproduction the combining cells may be either similar or dissimilar. If the cells be similar, the process of uniting is termed *Conjugation* (Fig. 293); if dissimilar, *Fertilization* or *Impregnation*. The cell formed by the union of two adjacent cells (Zygospore) only begins to subdivide and develop after a period of rest. In sexual reproduction the combining cells are unlike, and the product of their combination, however variously named, sooner or later begins to develop the new plant.

FIG. 293.



Conjugating Algæ (Zygnema).

Among Fungi both sexual and asexual reproduction occurs, but in some the process is as yet little understood. Throughout the group the plan of reproduction is very varied. The same may be said of each of the other divisions of Cryptogams, the brief enumeration of which kind of processes would serve no useful purpose.

II. REPRODUCTION AMONG THE PHANEROGAMS.

Phanerogamous plants are distinguished by possessing *stamens* and *pistils*, the former producing pollen, the latter *ovules*, which, when fertilized by the pollen, change into *seeds* containing an *embryo*. There is a considerable difference between the mode of reproduction as seen in the Gymnosperms and that of the Angiosperms, so that the processes will be described separately; but as the pollen is produced in the same way in both, it will be advisable to treat of it first.

Pollen.

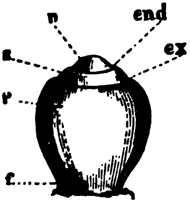
The anther, which is ultimately to form and contain the pollen, first appears as a small sessile, cellular protuberance, afterwards, in most cases, becoming stalked by the development of a filament. In its earliest condition the anther is perfectly solid. After a time the cellular mass in its interior becomes altered in two or more, usually in four spots, where a mass of very large cells are formed, each mass being surrounded by a layer of smaller cells, which ultimately forms the lining membrane of each cell in the anther. In many cases the two masses on either side of the connective, coalesce and constitute a single mass, so that the anther is bilocular, but in others they remain quite distinct, so that the anther possesses four cavities.

The large cells just mentioned are what are called the *parent*, or *mother cells*, of the pollen, for each forms in its interior four other cells or bodies which are ultimately set free by the rupture of their mother cell, and constitute the pollen grains. In some cases the absorption of the special mother cells is not complete, so that the pollen grains remain connected the one with the other. The pollen masses of the Orchidaceæ appear to be connected in this manner. Each pollen grain possesses two coverings—an internal, termed *Intine*, which is continuous, and an outer, called *Extine*, which is usually ornamented by special markings, and always presents one or more slits, or pores, or thinnings in its walls. The contents of the pollen grains go by the name of *fovilla*, and consist of oily matters, with granules, often starchy in their nature, thus presenting a marked contrast to the sperm cells of the higher Cryptogamia, which always contain a ciliated spermatozoid. The pollen grains of Gymnosperms are *not* simple cells, but contain a number of minute cellular *bodies*, which collect in the interior of each grain opposite the opening in the extine.

The Ovule.

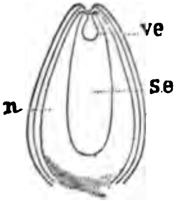
In all Phanerogamia the *ovule* first appears as a small cellular protuberance from the placenta, which gradually expands and becomes the *nucleus*. At the same time, it acquires certain coats (Fig. 294), the internal being first developed. These coats do not completely cover the nucleus, but leave a small orifice termed the *micropyle* at its apex, through which the pollen tube may pass. This

FIG. 294.



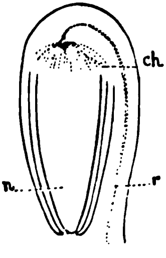
Orthotropous Ovule and Coats (Polygonum). *f*, Funiculus; *p*, Primine, last developed; *s*, Secundine, first developed; *n*, Nucleus; *end*, Endostome; *ex*, Exostome.

FIG. 295.



Fecundated Orthotropous Ovule. *n*, Nucleus; *v e*, Embryonal vesicle; *s e*, Embryo sac.

FIG. 296.

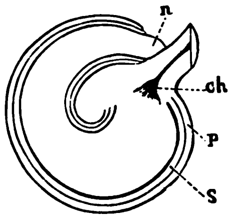


The most frequent form of Anatropous Ovule. *ch*, Chalaza; *r*, Raphe; *n*, Nucleus.

opening is sometimes formed by the inner coat only. When only one integument is developed, this often becomes thick and solid.

In the interior of the nucleus one cell becomes greatly enlarged, and constitutes the *embryo sac* (Fig. 295). The

FIG. 297.



Vertical section of a Campylotropous Ovule.
n, Nucleus; *s*, Secundine; *p*, Primine; *ch*, Chalaza.

spot where the substance of the nucleus becomes continuous with its coverings is called the *Chalaza* (Fig. 296), and the organ which attaches the ovule to the placenta is the *Podosperm* or *Funiculus*.

A. THE REPRODUCTION OF GYMNOSPERMS.

The ovules of the Gymnospermia (Pines and their allies) are not contained in cases but grow on the surfaces of an open carpel, so that the pollen has direct access to them, and they have only one coat except in the Podocarpeæ. The embryo sac is formed by the enlargement of a cell in the nucleus lining near its axis, and at some depth from the apex. In Taxus several cells are formed, but only one as a rule gives rise to the embryo sac. The nucleus of this cell is soon absorbed, whilst nuclei are formed in the surrounding protoplasm where cell formation takes place round them. These cells unite and then divide so that the embryo sac is filled with a fine parenchyma. Several embryo sacs may begin in one nucleus, but only one comes to maturity. Within the small celled tissue arise the *archegonia* or *corpuscula* in varying numbers. The pollen tube penetrates the nucleus, and fertilizes the central cell of the archegonium. The pro-embryo is here formed. The cells of this are at first small, but certain of these develop, producing what are called *suspensors*, which break through the central cell. Each of these suspensors may develop at its extremity the rudiment of an embryo. In this way and also because several archegonia may be produced in the same ovule, more than one embryo may be produced. As a rule only one of these ever comes to maturity.

B. THE REPRODUCTION OF ANGIOSPERMS.

The embryo sac in Angiosperms consists of a single large cell surrounded by a small cell growth. Sometimes, but rarely, more than one embryo sac may be thus formed. As the embryo sac grows, its surrounding walls become thinner and thinner. The protoplasm of the embryo sac also undergoes change, first vacuoles form in it and then a large sap cavity makes its appearance with masses of cells above and below. In the apical mass of cells is found the *embryonal* or *germinal vesicle* (Fig. 295), from which the embryo is formed. Two embryonic vesicles are usually formed, but one may disappear even before fertilization.

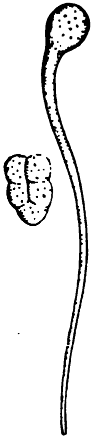
Fertilization is effected by one or other of the pollen grains which have reached the stigma. There they undergo a kind of germination, and the *intine* sends out a process which passes down through the conducting tissue of the style to the cavity of the ovary (Figs. 298 and 299). Here the pollen tubes are guided in various ways to the micropyle of the ovule. Each ovule requires one pollen tube for its fertilization, but the number of pollen tubes generally exceeds that of the ovules.

Various periods elapse between the application of the pollen to the stigma and the fertilization of the ovule. Days, weeks, and even months may intervene between the two. In some instances the pollen tube attains an enormous length. It is at first slender, but may acquire thickened walls. Sometimes its channel also increases in diameter.

The pollen tube may extend down to the embryo sac, or the embryonal vesicle may rise to meet it. Most frequently the tube has to make its way through a portion of the tissue of the nucleus. The wall of this is often weak, and may be pushed before the pollen tube. In

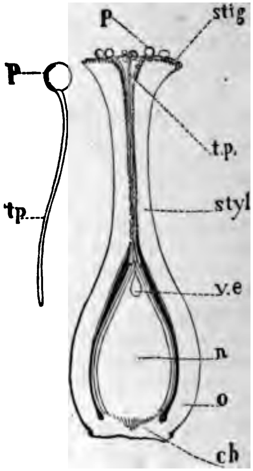
Canna perforation takes place. In any way contact of the pollen tube with the embryonal vesicle is all that is

FIG. 298.



Pollen masses and Pollen tube (Orchis).

FIG. 299.



Vertical section of pistil of Polygonum during fecundation. ***p***, Pollen; ***t p***, Pollen tube; ***v e***, Embryonal vesicle; ***n***, Nucleus; ***o***, Ovary; ***ch***, Chalaza; ***stig***, Stigma; ***styl***, Style.

necessary for fertilization. With that the fertilizing substance makes its way through the double wall into the interior of the embryonal vesicle, and the reproduction of a new being begins.

Three principal opinions have prevailed as to the exact relations of the pollen tube to the embryo—viz., Schleiden's, Meyen's, and Amici's, which last is the one now universally adopted.

In 1837, *Schleiden* brought forward the opinion that, *in* the ovule, one cell was transformed into an embryo *sac, and* was then gradually filled up with the cells which *constitute* the albumen of the seed; that the pollen tube ssed down through the style until it reached the ovule, ich it penetrated as far as the embryo sac; that this turn was also pierced, and that the point of the pollen be formed the rudiments of the embryo, while the other rt remained as its suspensor. This view, reversing as did all former notions as to the sexes of plants, received e most vehement opposition, and the result has been complete refutation.

Meyen, by examining various species of Mesembryanemums, conceived that there was an adhesion of the llen tube to the embryo sac, that a communication was med between them, and that the formation of an emyo was consequent upon the discharge of some of the ntents of the pollen tube into the interior of the embryo c.

Amici's views, as confirmed by Mohl, are as follows: fore the pollen tube reaches the ovule, certain changes ve taken place. When the pollen tube reaches the bryonal vesicle, there is an interchange of their ntents without any rupture of the embryo sac whater. By this means the vesicle is fertilized. Such is e view usually entertained as to the mode of reproction in Phanerogams.

The Embryo.

Immediately after fertilization the nucleus of the bryonal vesicle disappears, and in no long time the bryonal vesicle acquires for itself a cellulose coat if it s not done so before. Usually the endosperm has begun form before fertilization, but if not it now rapidly ows. The cells are at first spherical and unconnected, d may form only a parietal layer in the embryo sac, ich is filled with fluid; the best example of this on the ge scale is the Cocoa-nut. Various modifications are n in different plants, in a few the endosperm is almost dimentary, but in most it fills to a greater or less tent the embryo sac. The remains of the ovular nucleus y be retained, and become a reservoir of nourishment, us replacing the endosperm. In many Dicotyledons e cotyledons of the embryo become filled with nourishnt instead of having it in the form of endosperm. ch seeds are described as exalbuminous in contradisction to those having an endosperm which are spoken *as albuminous.*

The *Embryo* is not formed directly from the embryonal vesicle. The end of this last named body next the micropyle coalesces with the wall of the embryo sac, whilst that next the base of the ovule lengthens and divides. In this way is formed what is termed the *pro-embryo* or more commonly the *suspensor*. The lower end of this enlarges and then subdivides, growing rapidly so as to form a mass of small celled tissue, and this is the embryo. The various parts of the embryo plumule, radicle, and cotyledons are soon shadowed forth, the radicle being directed towards the apex of the ovule. With the maturation of the embryo and its endosperm the seed is ripe and fit for reproduction.

HYBRIDIZATION.

When the pollen of one species of plant is applied to the stigma of another closely allied to it, should impregnation take place, the resulting individual will present a set of characters intermediate between those of the two parents; not, however, an exactly equal mixture, for sometimes the male influence, sometimes that of the female, will be paramount. Such an individual is termed a Hybrid. Should the alliance have taken place (which it very rarely does) between closely related *genera*, the new individual will be termed a *bigener*. The propagation of hybrids is rarely effected by seeds, as they always tend to revert to the original stock, and is usually effected by grafts or cuttings. Hybrids rarely occur in nature, being usually produced artificially.

CHAPTER VII.

THE FRUIT.

FTER fecundation, certain changes are observable in the stil which end by converting it into what is called the *ruit.* The fruit is never perfect except it contain seeds pable of germinating. Many of the fruits which are ost valued for food do not contain seeds, as is often the se with the orange, the vine, and the pine apple. Such edless fruit seems to be most frequently produced on d trees. The formation of perfect fruit is the crowning t of vegetable life, and many plants die as if from exustion immediately after. Others, however, continue bear fruit year after year for very long periods. The rmer have been termed *Monocarpic,* the latter *Polyrpic* plants.

Many artifices are had recourse to for the purpose of nproving the quality, or increasing the quantity of uit on cultivated trees. Among these may be enuerated the application of manure, pruning, ringing, and inning, the last being employed when the quantity of ung wood is too large for the tree to bear.

When in their young state, and so long as they retain green colour, fruits act on the atmosphere in the same ay as leaves. Frequently, however, as the fruit ripens, anges in colour take place, and the succulent rind may ecome hard and bony, as is seen in nuts. Simulneously with these, other changes, which in some cases t least are of far greater importance to mankind, go on. ruits, which at first are tasteless, consisting mostly of llular tissue or woody fibre, first become sour by the evelopment of such acids as the citric or malic, and fterwards sweet from the conversion of this into sugar, nd its partial neutralization by an alkali. Along with ese compounds the peculiar substances which give avour to fruits are developed. Another substance, und in fruits, is called pectic acid. This gives them heir power of forming a jelly. As to the time required or the ripening of fruits no rule can be laid down, the variations are so great. In most cases the period of ripening can be shortened by the application of heat as in forcing houses. Some fruits, as the medlar, are improved by what is called *bletting—i.e.*, exposure to a moderate temperature, after separation from the tree, till they attain a state intermediate between ripeness and putrefaction.

CHAPTER VIII.

THE SEED.

When the seed is mature, it usually separates from the parent plant either with the fruit, or after the fruit has opened to permit its escape. Some plants ripen their fruit underground, and are called Hypocarpogean; others, again, produce seeds having wings or hairs for support in the air while they are carried from one place to another by the wind. Streams and animals are also important agents in the scattering of seeds. To make up for the destruction, which is inevitable, most plants produce a great many more seeds than are absolutely necessary for the propagation of the species, in some instances the number being enormous, amounting, in the case of a single tobacco-plant, to upwards of 40,000.

Vitality of Seeds.—Some seeds must be sown almost immediately after ripening, or they will not germinate; others may be kept for indefinite periods without losing the same power. This power of germination is termed the "vitality of seeds," and may have entirely disappeared without the seed having lost any of the properties which fit it for food. Seeds having very delicate integuments do not keep well, while those possessing a hard covering may be preserved intact for a very long time. Leguminous seeds long retain their vitality, those of Compositæ and Cruciferæ for a short period only.

Seeds having oily albumen or containing much tannin keep very badly; those which have no albumen, or that only of a mealy kind, may be preserved much longer. Such seeds as are properly ripened and well dried, keep better than those that have been gathered early, and in a moist condition.

In transporting seeds from one country to another, two plans may be adopted—either they may, after proper drying, be exposed to the air, or they may be packed in a substance which does not attract moisture, and will, at the same time, hinder the access of the atmosphere. It is said that, when coated with wax, very delicate seeds may be conveyed a great distance without injury.

Germination.

When a ripe seed is placed in proper conditions the embryo becomes active, enlarges, and bursts its surrounding integuments, giving rise to a new plant. This is called GERMINATION, and the chief conditions necessary for it are *heat*, *moisture*, and *air* or *oxygen*, while it is favoured by the *absence of light*, and according to some, by *electricity*. Some seeds germinate before they leave their parent, as in the Mangrove, but this is unusual.

The amount of *heat* required by germinating plants varies greatly: that which is most favourable to the majority is a temperature of from 60° to 80° Fahr., though some tropical plants require a much greater amount, while some Cryptogams will germinate a very little above the freezing point.

So long as seeds are kept dry they will not sprout, but when *moisture* reaches them the embryo begins to develope. By the absorption of water the cells of the seed become distended, and their integuments are ruptured, allowing the exit of the embryo. At the same time by the action of *heat* a substance termed *diastase* (a sort of ferment) is developed, which converts the starch of the embryo into dextrin, and grape sugar — substances capable of nourishing the plant.

To effect these changes, *oxygen* or *air* is necessary; carbonic acid is given off, and heat is evolved. When buried deeply in the soil seeds do not germinate, but may lie dormant for many years till exposed to the proper conditions of vegetative growth. Substances which evolve oxygen favour germination.

Seeds sprout more readily in the *dark* than in the light, and more readily when in diffuse daylight than in direct sunlight, while the chemical rays of the solar spectrum favour germination more than light-giving rays.

Opinions as to the beneficial effects to be derived from *electricity* vary considerably; probably a small amount is favourable to the development of the embryo.

The conditions most favourable to germination will, therefore, be deposition of the seeds at a moderate depth in the soil, which should be well pulverized to allow the admission of air, and hinder the escape of heat and moisture, well drained to prevent accumulation of water;

but with a sufficient supply of water for the wants of the seed and young plant, and a certain amount of heat. Small seeds should not be planted at so great a depth as the larger ones. The time required for the germination of seeds varies greatly, being least in those which take up water most readily, and longest in such as have been dried and possess a dense coat. Soaking such seeds in water previous to sowing or planting considerably hastens the appearance of the embryo.

Germination of Monocotyledons. — In many Monocotyledons the embryo appears to have no distinction of parts, but looks a simple conical mass, almost truncated at the one extremity, tapering to the other, and with a slit towards its base. From the truncated extremity the adventitious roots are developed, and through the slit the plumule makes its appearance, while the tapering portion is the solitary cotyledon. The radicle itself is never developed to any extent, but from it are developed adventitious roots, which pierce the outer covering of the radicle in the manner formerly described. Most monocotyledonous seeds have a supply of albumen, which is usually, though not always, entirely absorbed; and in them the solitary cotyledon is partially or wholly retained within the seed-coat during the germination.

Germination of Dicotyledons.—The seeds of Dicotyledons have a supply of nourishment either in the embryo itself (especially in the cotyledons) or in the form of endosperm round about it. When such seeds begin to sprout, the radicle first makes its appearance at the foramen or micropyle, and then the cotyledons protrude. In some cases the cotyledons rise above ground in the shape of leaves, when they are said to be *epigeal;* in others, they remain below ground, and are termed *hypogeal.* The plumule makes its appearance between the two cotyledons, which are sometimes so cut up as to make the embryo appear *polycotyledonous*, as in the Coniferæ. The shape of the cotyledonary leaves bears no necessary relation to that of the true or vegetative leaves.

Direction of the Root and Stem.—Why the plumule should always grow upwards, and the radicle downwards, has never been properly explained. Some have assigned as the reason that the plumule always seeks light and dryness, *the radicle* moisture and darkness; but this has been proved to be incorrect. Knight attributed it to gravitation acting on the nutrient fluids, distributed in a peculiar manner—viz., to the point of the radicle and the lower side of the plumule; Dutrochet accounted for the phenomenon by gravitation of fluid taking place towards the lower surface, and preventing endosmose. Altogether, little is really known as to the cause of this obscure though common phenomenon.

CHAPTER IX.

DEVELOPMENT OF HEAT BY PLANTS.

THE development of *heat* by plants has already been alluded to as taking place in flowers, and during germination. Besides this, however, in all probability other parts of plants have the power of evolving heat, from the absorption of oxygen and its conversion into carbonic acid (carbon dioxide).

The most marked production of heat is seen in germinating barley preparing for malt, and in the spadix of the Arum family during fertilisation. Under the last named condition the temperature may rise as much as 10° C. or more.

PHOSPHORESCENCE OF PLANTS.

The *luminosity of flowers* is now considered rather questionable. What appears to have been taken for it was the effect of brilliantly-coloured red or yellow flowers on the eye. Some fungi, however, as Agaricus olearius, do appear to give out light. This ceases with the death of the plant.

MOTION IN PLANTS.

There is no chapter in vegetable physiology more interesting and more attractive than that which refers to motion in plants. Some of these forms of motion have already been discussed. Such are the movements of protoplasm as seen in individual cells, the motion of sap, &c. Here we refer to certain periodic movements, seen more especially in leaves and their modifications, and to those still more curious phenomena seen in the motions of the Sensitive plant, in Drosera, and Dionæa. Altogether there might be described three forms of motion among plants:—

1st. One which might be described as *spontaneous*, as occurring without any apparent stimulus.

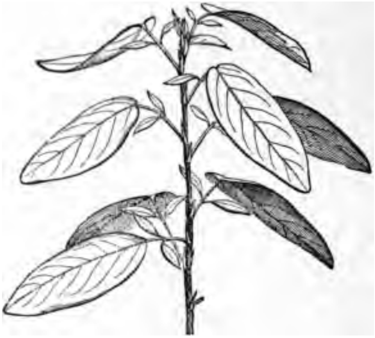
2nd. The well-known movements implied by what is called the *sleep of plants*. Here the stimulus to keep the leaves or flowers open is probably light, with in some instances heat, so that in the absence of these, as at night, the plants close or go to sleep.

3rd. The motion due to *concussion*, or to the *irritation* by touch or otherwise, of some spot on the leaf, causing it to close, as in the Dionæa and Drosera.

Of the first variety we can give no better example than that of the Desmodium or Hedysarum gyrans, the Indian Telegraph plant.

In this instance we have a compound leaf, the terminal leaflet being very much larger than the two lateral ones (Fig. 300). These two lateral leaflets are supported by slender petiolules, and at an ordinary temperature are in constant motion upwards and downwards, like the arms of the old telegraph or the more modern railway signal poles. These movements do not depend on light, but the great leaflet seems subject to its influence, occupying a more or less horizontal position during the day, but becoming flattened down to the stem at night.

FIG. 300.

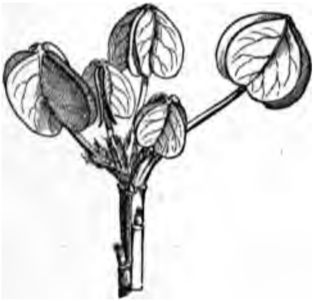


The Telegraph plant, with large terminal leaflet and two small lateral leaflets.

Of the second kind examples are familiar enough, none more so than in the leaves of the Wood Sorrel (Fig. 301), which at night become folded down to the stem or petiole. But here also we have folding produced by other causes, as roughly handling the stem or pulling it up from the ground. A similar phenomenon to the last is seen in the folding of the flowers of the Wood Anemone when they are pulled and carried in the hand.

In most of these instances there can be little doubt but that the movement is due to purely physical causes, to the sudden alteration of tension in one set of cells compared with another set, compelling the row of tense cells to assume a curved instead of a straight position. This kind of phenomenon is best exemplified by a common experiment in physics. Two bars of metal, which expand to different extents on the application of the same degree of heat, are securely fastened together so as to form a single bar. On applying heat to the compound bar, the more expansible metal expands more rapidly than its neighbour, but being fixed to the other does not expand in a straight direction, and consequently becomes the convexity of a curve. Such in all probability is the explanation of many motions in plants where, however, water or cell-sap is the distending power. This, coupled with our knowledge of the elasticity of cell-walls, helps us to form some idea of the mode in which the problem may be solved, even in the

FIG. 301.

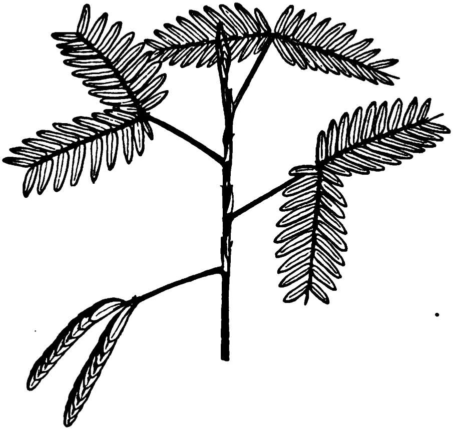


Leaves of Oxalis asleep.

case of such sudden, complete, and extensive motion as may be seen on giving a sharp shake to the Sensitive plant (Mimosa pudica) (Fig. 302).

In the third form of movement in plants as exhibited by Dionæa muscipula (Venus Fly-trap), and various species of Drosera, we have something much more wonderful and much more difficult of understanding. These plants really live on animal food, chiefly on flies and other insects which are attracted to them. The unlucky animals

FIG. 302.



Sensitive plant—one of the compound leaves folded up.

reach a given spot, the irritation production by their feet or by their slight weight is sufficient to excite movement in the unstable leaves, which suddenly close, and in so doing impale the wandering insect on a series of spines arranged apparently for the purpose. Not only so, but the leaf has the power of secreting a digestive fluid whereby the bodies of its prey are dissolved and probably converted into its own substance. Moreover, it has been proved that in these movements, the same electric phenomena are manifested as take place in contracting muscle. This admits of clear and definite demonstration.* We have in this instance to do with phenomena of a different kind in all probability—though this is not proved—from those seen in the other instances of plant motion. Apparently they approximate much more to the protoplasmic movements seen in some of the Algæ than to these, and by such protoplasmic movement we must meanwhile consent to explain the phenomena.

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* See Darwin's book on Insectivorous Plants.

PART III.

VEGETABLE NOSOLOGY, OR VEGETABLE PATHOLOGY.

THERE are few parts of Botany so interesting to all as the DISEASES OF PLANTS, and yet we are almost entirely ignorant of them. To the medical man they are of importance, as showing disease in its simplest condition; to the agriculturist they are of importance, as threatening to ruin his crops; while the potato disease and the distress which resulted therefrom showed how important the subject was to the whole community. The principal diseases may be classified under three very distinct heads—1st, Those dependent on abnormalities of the ordinary conditions of vegetable life; 2nd, Those dependent on causes superadded to the ordinary conditions of vegetable life; and 3rd, Diseases dependent on the attacks of animal and vegetable parasites.

1. *Diseases dependent on Abnormalities of the Ordinary Conditions of Vegetable Life.*—When plants grow in a poor soil they become stunted, weak, and unusually liable to disease. Frost often destroys plants in this climate, or renders them liable to other diseases. The period when it is most prejudicial is just after active vegetative life has commenced. Many plants will bear considerable variations of temperature and climate, though when grown in cold climates they may not produce substances like those produced in warm, as is seen in Indian hemp, which in India produces a powerful medicinal resin, but none in this country. The health of plants depends more on the extremes of heat and cold endured at any spot than on [illegible] mean temperature. The same is true as regards the [illegible] of mankind, hence the flora of any place is always [illegible]portant guide to the nature of its climate. Absence

of light also acts powerfully as a cause of disease, the plants become pale and sickly-looking, the cells developed do not harden, so that the tissues are soft and brittle. This is artificially imitated in the process termed blanching. Too much heat often causes abortion of stamens and pistils, while too great absorption, when not counterbalanced by evaporation, causes dropsy; when, again, evaporation is too great, defoliation takes place. Such a result often ensues from keeping plants improperly protected in a warm room.

2. *Diseases from superadded Conditions.*—As already noticed, certain gases act very injuriously on vegetables, as hydrochloric and sulphurous acids, and chlorine gas, as also hydrosulphuric acid, though acting in a different way. Substances may be absorbed by the roots, which will have the same prejudicial effect, as most of the mineral irritants, and some of the vegetable poisons.

3. But by far the greatest number of the diseases to which plants are liable depend on *parasites*, more especially the vegetable ones. Of these parasitic diseases *fungi* are by far the most important sources; their spores are so small, and readily float in the air. They are thus ready to seize on any plant which will afford them a proper nidus. They attack all parts of the plant, but different species attack different plants, or even different parts of the same plant, and sometimes a considerable number produce similar effects on different plants.

That disease of wheat known as *Bunt*, *Smut-balls*, or *Peppercorn*, is produced by a fungus (Uredo Caries, or U. fœtida), which consists of little bundles of dark globules attached to a mycelium. The spores have a fœtid odour. Steeping the grain in water and the use of alkalies have been recommended as a preventive and as a remedy.

Smut or *Dust-brand* is caused by another Uredo (Segetum), whose spores are not so large, and possess no fœtid odour. When the corn has been destroyed, this appears between the scales as a black powder. This disease is commonest in Oats.

Rust is produced by Uredo rubigo: it attacks the stem leaf and chaff of grasses, producing yellow spots. Another well-known disease is *Mildew*, produced by a fungus called Puccinia graminis. It attacks wheat, and appears to enter *by the stomata* in the condition of spore. The fungus appears above the epidermis in the form of club-shaped clusters of spores. Sulphate of copper and common salt have been used as a pickle to prevent its appearance. Grain affected by it floats in water, and this has been used as a means of separating the diseased portions, while scalding has been employed to destroy the fungus, though it does not affect the wheat itself. A kind of smut attacks Maize produced by a species of Ustilago (Maydis), which seizes upon almost every part of the plant. Other grasses are affected in like manner. Mildew of the Vine is produced by an Oïdium.

One of the most important of diseased grains is Ergot, produced, more especially in unimpregnated rye, by Cordyliceps purpurea. The grain is removed, and its place taken by the mycelium of this fungus. Ergot is a valuable medicine, but if bread made of rye containing much of it be long eaten it gives rise to serious diseases of various kinds.

As to the cause of the Potato disease, many opinions prevail, all holding that a fungus is developed in the diseased tuber, but differing as to whether this is a cause or a consequence of the disease. The fungus is termed Botrytis infestans, and attacks all parts of the plant very rapidly, beginning with the leaves, which assume an appearance like those acted on by sulphurous acid or other irritant gases.

Timber, whether alive or dead, when exposed to damp in a still atmosphere, is attacked by what is termed the *Dry Rot.* The wood begins to decay, and thus furnishes a soil for the fungi, which are soon developed. The fungi are chiefly Merulius vastator, and Polyporus destructor. As soon as these begin to develop, their mycelium spread with great rapidity, and deprives the wood cells of their contents, so that the wood becomes brittle. When wood is allowed to dry properly, and exposed freely to the air, it is not so likely to be attacked. To preserve wood from this so called dry rot, various substances, such as corrosive sublimate and creasote (as in creasoting railway sleepers), have been employed to coagulate the albumen contained in it. Chloride of zinc has also been used for the same purpose. Dodder, a phanerogamous parasite, often attacks flax and clover, and is very injurious to them.

Allusion can only be made here to the belief that most of the epidemic disorders attacking mankind are due to parasitic fungi.

The disease which attacks wheat, known as Ear-cockle, is caused by small vibriones which make their way into the interior of the grain, which they entirely destroy, and replace by a cottony substance. Scalding water destroys the vibriones. Many insects are destructive to vegetation—some, like the locust, destroying everything before them, others selecting one particular plant for their ravages. A species of Cecidomya attacks wheat, and inflicts great injury on it. Aphides or plant-lice are found on almost every variety of plant, and increase with enormous rapidity; fortunately, they are destroyed in great numbers by the little beetle called the "Lady-bird." Cochineal is produced by a Coccus which attacks the Cactus plant, and galls by a Cynips or Diplolepis, which deposits its eggs on the oak. Besides these, an almost infinite variety of insects infest vegetables, and many prove very destructive, though few are so much so as the larvæ of a beetle called Elater, the well-known and dreaded "Wireworm." This animal is cylindrical in shape, of a yellowish colour, marked with rings, and having a hard skin. A crop of white mustard appears to have the power of destroying them, but crows are their prime enemies.

Such extensive and important subjects as the silkworm disease, the vine disease, and the decay of vines can be only referred to in passing.

PART IV.

SYSTEMATIC BOTANY.

PRINCIPLES OF CLASSIFICATION.

To arrange the endless variety of plants existing all over the world into groups marked by some common character, is the aim of Systematic Botany. This purpose may be effected in two ways—1st, either some prominent character is selected, and all plants arranged with regard to the possession or want of that character; or, 2ndly, all the characteristics of the plant are taken into account, and it is placed according to the sum of these, not according to any one of them. Such a grouping as that indicated in the first place constitutes what is called an Artificial System of Classification; but the second, seeing that it aims at distributing plants according to their true relationships, is called the Natural System par excellence.

In attempting any classification, the first objects of attention are *Individuals*, but it is much easier to moot the question what an individual really is than to answer it. Ordinarily each plant is looked upon as constituting an individual, so long as it forms an entire mass and no longer. This is evidently a very unphilosophical way of viewing the matter, for it often happens that the part thus removed is capable of an independent existence, and may become exactly like the original plant, as is seen in grafting, &c. The new plant in this case cannot be looked upon as an individual, seeing it is but the part of one. To get over this difficulty, some botanists, as Thouars and Braun, regard as the true individual the original shoot springing from the seed, and each bud repeating it as a new individual; but this view is liable to exactly the same objection as the former one, for as each plant can be resolved into a number of buds, so each bud can be resolved into a number of *phytons*, or the distinct beings which each leaf is supposed to represent. Others again look upôn the product of one seed as constituting an individual; were this so, every plant propagated from a cutting would only be the repetition of one plant, so that all the potatoes in the country might be supposed to constitute a single individual.

Species.—The first step in the grouping of individuals is to gather together all those which more nearly resemble each other than they do any other plant. Such a group is termed a *species.* Now, as all plants tend to reproduce themselves, their offspring being as nearly like the parents as possible, any peculiarities possessed by this parent will be transmitted to future generations, so that by this means the species may be perpetuated. This tendency to the transmission of peculiarities from parent to offspring has also been seized upon for defining species, which are by some said to be constituted by *all those individuals, so closely resembling each other that they either have, or may have, originated from one common parent.* When the pollen of one plant comes in contact with the ovule of another exactly similar, fecundation takes place, and a seed is produced which gives rise under the proper circumstances to a new individual exactly similar to the parents. Should, however, the plants be not so closely related, fertilization might still take place, but the new plant produced by the seed would not be exactly similar to either of the parents, and would be unable to reproduce itself except when fecundated by a plant exactly like the parent. By this means any differences between parent and offspring would tend to disappear in the next generation. Plants which *are capable of producing fertile young*, are said to belong to the *same species*, those which produce plants capable of fecundation by the parents only, are said to belong to *distinct species*, the result of their intermixture being termed a *hybrid.* Should the plants be still more remotely connected, fecundation would probably not be effected at all.

Varieties.—Should two seeds, say from the same pod, be sown, the *one in* a light soil, in a bright and sunny situation, the other in damp, heavy soil, and in a dark situation, the resulting plants may be widely different.

The tendency of all plants is to repeat the peculiarities of their ancestors, so that the descendants of the plant grown in the one situation will centinue to differ from those grown in the other, more especially if the original causes of the variation continue in operation. One of the most vexed questions in Natural Science at the present day is, whether these variations are limited or unlimited; whether a plant can ever, by the long-continued operation of external causes, be ever made to change its species, or whether the changes are limited within a certain range, never amounting to the transmutation of species, but merely to those subordinate groups already indicated, and termed *Varieties.*

When, by continued cultivation or from any other cause, the characteristics of a variety become tolerably fixed and permanent, so as to be transmissible by seed and not by cuttings merely, as is usually the case with varieties, the variety becomes a *Race.* Such a condition is seen in most of our cultivated plants.

A *Species* might be defined as all those plants so closely resembling each other that they either have, or may have, originated from a common parent, and which by intermixture are capable of producing fertile descendants.

A *Variety* comprehends all those individuals whose characters have been altered by soil, climate, &c., but which, when propagated by seed, tend to return to the parent stock.

A *Race* is an unusually permanent variety, whose peculiar characters are with tolerable certainty transmissible by seed.

Genus.—As is the case with individuals, so is it with species. Some have a greater general or particular resemblance to each other than they have to any other species whatever, and may therefore be collected into a group, characterized by the possession of the common characters or points of resemblance. Such a group is denominated a *Genus.*

All genera are not, however, equally extensive: thus it sometimes happens that a great many species resemble each other very closely, and yet are markedly dissimilar from all others, while again it sometimes occurs that a single species may be isolated from all others by the possession of some one peculiarly marked characteristic; hence there are *extensive* genera and *small* genera.

Orders or Families.—As species are grouped together into genera, so genera are grouped together into *Orders* or *Families*, as they are interchangeably called. These are in fact genera of genera. Sometimes several of the genera possessing all the characters of the order are characterized by the possession of something which distinguishes them from the other plants possessing the ordinal characters; such divisions are termed *Sub-orders.*

Class.—Classes are to orders what orders are to genera—they express the most extensive relations known to exist in the vegetable kingdom.

The principal divisions of the kingdom might therefore be arranged thus—

Kingdom.
Class.
Order or Family.
Suborder.
Genus.
Species.
Variety.
Individuals.

Many botanists are of opinion that, with the exception of species, there are no real groups in nature, while others think that even these are fortuitous, not absolute and unchangeable.

Nomenclature.—Ever since the time of Linnæus, plants have been distinguished by two names—the first or generic appellation, indicating the *genus* to which the plant is referable; the second the *specific* or *trivial*, as it is also called, marking the particular species of that genus to which the plant belongs. The generic name applies to all the plants of the genus, but to none of any other; whereas the specific, though it can only be used for one species in one genus, may be used in any number of genera. Thus the two genera, Helleborus and Hyoscyamus, are indicated by these names, and no other genus belonging to any other class is liable to be mistaken for them, neither is any plant liable to be mistaken for Helleborus Niger or for Hyoscyamus

Niger, though the same specific name is used in both cases.

The origin of the generic title is very varied, sometimes, as in Quercus, being the classical term, sometimes the native name latinized, as Bambusa, the Bamboo; sometimes the Greek form is employed, as Menispermum for Moonseed, and so on. Others take their names from their discoverer, or some famous botanist, as Linnæa, Richardia, &c.

Specific names are either adjectives, or words used as such, often characteristic of some peculiarity of the plant —as Viola tricolor, Papaver somniferum, &c.; sometimes of the habitat of the plant, as Sanguinaria Canadensis; sometimes of the discoverer, or of some botanist not connected with the discovery. When the specific name is given after the discoverer, the genitive form should be used, as Nectandra *Rodiœi;* when named after any botanist not the discoverer, the adjective form should be preferred, as Veronica *Lindleyana*, but this rule is not strictly adhered to.

As a rule, the generic name should begin with a capital letter, the specific name with a small one, except the specific name has at one time been employed to designate what was supposed to be a genus, Polygala Senega, Cissampelos Pareira, &c., or, in accordance with the general rule, has been derived from a proper name.

As it must sometimes, and unfortunately too often does happen, that two or more persons should give different names to the same plant, either simultaneously or at different periods, it is necessary, when once this has been made clear, to state which author's views as to nomenclature have been followed. With this end in view, it is common to append the initial letters of the botanist's name to the nomenclature adopted in the case of any plant. Thus—

Br.	stands for	Robert Brown.
D. C. or De Cand.	„	De Candolle.
Juss.	„	Jussieu.
Hook.	„	Hooker.
Lindl.	„	Lindley.
Rich.	„	Richard.
Wild.	„	Willdenow, &c.

SYSTEMS OF CLASSIFICATION.

As previously pointed out, plants may be arranged by any one feature selected for the purpose according to what is termed an *Artificial scheme* or *System*, as in that of Linnæus, where the reproductive organs were chosen; but it must be evident that such a classification will serve no other end than that of enabling any person to find out the name of a plant with tolerable ease, while it is also evident that it must violently sever plants, which, though closely allied in every respect, may differ in the particular organ selected as the ground of classification. What is called the *Natural System*, on the other hand, aims at bringing all naturally allied plants together, no single character being allowed to preponderate in the selection of a proper place for the plant.

1. LINNÆAN SYSTEM.

Of artificial systems, by far the most celebrated is that of Linnæus, which from the nature of the organs chosen as the ground of classification, is sometimes also called the *Sexual System*. In this system all the species belonging to one genus, are kept under a single heading, whether they possess all the characters or not, the genera alone being arranged in an arbitrary manner according to the selected character, just as the words in a dictionary are arranged according to their initial letters, though those closest together may have nothing else in common.

The classes and orders were founded on the number, situation, size, and connexion of the stamens and pistils.

The classes were twenty-four in number, of which the first *eleven* had reference solely to the *number* of stamens; the next two to their *position;* the next two to their *relative size;* another five to their *connexion;* and three more to the position of the male and female organs on the same or separate plants; while the last group comprehended all those plants which had no evident sexual organs (Cryptogamia).

LINNÆAN CLASSIFICATION.

	I.	1 stamen	1.	Monandria	Ex. Hippuris.
	II.	2 stamens	2.	Diandria	Ex. Ash.
	III.	3 stamens	3.	Triandria	Ex. Grasses.
	IV.	4 stamens	4.	Tetrandria	Ex. Plantain.
	V.	5 stamens	5.	Pentandria	Ex. Most Dicotyledons.
	VI.	6 stamens	6.	Hexandria	Ex. Lily.
	VII.	7 stamens	7.	Heptandria	Ex. Horse-chestnut.
	VIII.	8 stamens	8.	Octandria	Ex. Heath.
	IX.	9 stamens	9.	Enneandria	Ex. Rhubarb.
	X.	10-12 stamens	10.	Decandria	Ex. Saxifrage and many Dicotyledons.
	XI.	12-20 stamens	11.	Dodecandria	Ex. Mignonette, &c.
	XII.	20 or more perigynous stamens	12.	Icosandria	Ex. Rosaceæ.
	XIII.	20 or more hypogynous stamens	13.	Polyandria	Ex. Ranunculus.
	XIV.	2 long and 2 short stamens	14.	Didynamia	Ex. Labiatæ.
	XV.	4 long and 2 short stamens	15.	Tetradynamia	Ex. Cruciferæ.
Stamens coherent	XVI.	Filaments coherent in 1 bundle	16.	Monadelphia	Ex. Malvaceæ.
	XVII.	Filaments coherent in 2 bundles	17.	Diadelphia	Ex. Many Leguminosæ.
	XVIII.	Filaments coherent in more than 2.	18.	Polyadelphia	Ex. Hypericum.
	XIX.	Anthers coherent in 1	19.	Syngenesia	Ex. Compositæ.
	XX.	Stamens adherent to pistil	20.	Gynandria	Ex. Orchidaceæ.
	XXI.	Male and female organs in different flowers on same plant	21.	Monœcia	Ex. Arum.
	XXII.	Male and female flowers on different plants	22.	Diœcia	Ex. Willow.
	XXIII.	Male, female, and neuter flowers on same plant	23.	Polygamia	Ex. Many Palms.
	XXIV.	No reproductive organs apparent	24.	Cryptogamia	Ex. Ferns, &c.

The orders into which Linnæus divided the first thirteen classes were founded on the number of styles or stigmas present in each flower; thus—

Classes I. to XIII.

Monogynia, having 1 style, includes all the plants so furnished in the first 13 Linnæan Classes. Ex. Primrose.
Digynia, having 2 styles, as Grasses.
Trigynia, having 3 styles, as Rumex.
Tetragynia, having 4 styles, as Holly.
Pentagynia, having 5 styles, as Aconite.
Hexagynia, having 6 styles, as Butomus.
Heptagynia, having 7 styles,
Octogynia, having 8 styles, } no British representative.
Enneagynia, having 9 styles,
Decagynia, having 10 styles, as Phytolacca.
Dodecagynia, having 11 or 12 styles, as the House Leek.
Polygynia, having more than 12 styles, as Ranunculus.

Class XIV. is divided into two groups, according to the nature of the fruit:

Didynamia {
1. Gymnospermia (naked-seeded), fruit achenes mistaken for seeds, as in the Labiatæ.
2. Angiospermia (covered-seeded), seeds evidently covered, as in Scrophulariaceæ.

Class XV. is divided by the fruit, into Siliquosæ and Siliculosæ:

Tetradynamia {
1. Siliculosæ, fruit short and broad, as in Capsella.
2. Siliquosæ, fruit long and narrow, as in Mustard.

Classes XVI., XVII., and XVIII. are divided into eight orders, according to the number of stamens, which, being never less than three, makes Triandria the first order. Thus:

Mon- Di- and Polyadelphia {
Triandria, with 3 stamens, as Tamarind.
Pentandria, with 5 stamens, as Passiflora.
Hexandria, with 6 stamens, as Fumaria.
Heptandria, with 7 stamens, as Pelargonium.
Octandria, with 8 stamens, as Polygala.
Decandria, with 10 stamens, as Pea, &c.
Dodecandria, with 12-20 stamens, as Orange.
Polyandria, with more than 20 stamens, as Mallow.

Class XIX. at first contained all compound flowers and all flowers with united anthers, but afterwards Linnæus, by excluding the latter division, which he termed *Monogamia,* made the group a natural one, and equivalent to the Compositæ. It is divided into five orders, as follows:

1. Polygamia æqualis, where florets are all perfect (☿), as Dandelion.
2. Polygamia superflua, where the florets of the disc are perfect (☿), and those of the ray pistillate (♀) only. Ex. Daisy.
3. Polygamia frustranea, where the florets of the disc are perfect (☿), while those of the ray are neuter. Ex. Centaurea.
4. Polygamia necessaria, where the florets of the ray are male (♂), while those of the disc are (♀) female and fertile. Ex. Marigold.
5. Polygamia segregata, where each floret is surrounded by an involucel of its own. Ex. Echinops.

Classes XX., XXI., and XXII. are divided into orders by the number of stamens each possesses, and the cohesion or distinctness of these. Thus:

Gynandria Monœcia Diœcia	Monandria,	with 1	stamen.	Ex. Orchis.
	Diandria,	„ 2	„	Ex. Cypripedium.
	Triandria,	„ 3	„	Ex. Carex.
	Tetrandria,	„ 4	„	Ex. Nettle.
	Pentandria,	„ 5	„	Ex. Cannabis.
	Hexandria,	„ 6	„	Ex. Cocos.
	Octandria,	„ 8	„	Ex. Hazel.
	Enneandria,	„ 9	„	Ex. Mercurialis.
	Decandria,	„ 10	„	Ex.
	Dodecandria,	„ 12	„	Ex. Stratiotes.
	Polyandria,	„ ∞	„	Ex. Sagittaria.
	Monadelphia,	„ stamens in 1 bundle		Ex. Pines.
	Polyadelphia,	in several do.		Ex. Ricinus.

In Class XXIII. the orders are founded on the characters furnished by the position of the different kinds of flowers. Thus:

Polygamia	Monœcia, with perfect male (♂) and female (♀) flowers on same plant, as Acacia.
	Diœcia, with hermaphrodite (☿) flowers on one plant, and male (♂) and female (♀) on another, as Hippophaë.
	Triœcia, with hermaphrodite flowers on one plant, male on a second, and female on a third.

Class XXIV., or the Cryptogamia, were divided into six natural groups, viz.:

1. Filices	Ferns, &c.
2. Musci	Mosses.
3. Hepaticæ	Liverworts.
4. Lichenes	Lichens.
5. Fungi	Mushrooms.
6. Algæ	Seaweeds.

The following table, as arranged in Professor Balfour's "Class Book," shows at a glance the various relations of these groups.

A. Flowering Plants—Phanerogamia.

I. Stamens and pistils in every flower.

1. Stamens unconnected—

a. Stamens either of equal length, or at all events neither didynamous nor tetradynamous—

1 in number	Class I. Monandria	Order 1. Monogynia	1 free style.
2 "	II. Diandria	2. Digynia	2 free styles.
3 "	III. Triandria	3. Trigynia	3 "
4 "	IV. Tetrandria	4. Tetragynia	4 "
5 "	V. Pentandria	5. Pentagynia	5 "
6 "	VI. Hexandria	6. Hexagynia	6 "
7 "	VII. Heptandria	7. Heptagynia	7 "
8 "	VIII. Octandria	8. Octogynia	8. "
9 "	IX. Enneandria	9. Enneagynia	9 "
10 "	X. Decandria	10. Decagynia	10 "
12-19 "	XI. Dodecandria	11. Dodecagynia	11 "
20 or more, perigynous	XII. Icosandria	12. Polygynia	12 "
20 or more, hypogynous	XIII. Polyandria		

b. Stamens differing in length, in certain proportions—

Two long and two short	XIV. Didynamia	1. Gymnospermia	Fruit, achenes.
		2. Angiospermia	Fruit, capsular.
Four long and two short	XV. Tetradynamia	1. Siliculosa	Fruit, a silicula.
		2. Siliquosa	Fruit, a siliqua.

2. Stamens connected—

By their filaments in one parcel or tube	XVI. Monadelphia	Triandria	3 stamens.
By their filaments in two parcels	XVII. Diadelphia	Pentandria	5 stamens.
By their filaments in three or more parcels	XVIII. Polyadelphia	Decandria	10 stamens.
		Polyandria	numerous stamens.

And so on, as in the first 13 classes.

By their anthers (composite flowers)	XIX. Syngenesia	1. Polygamia æqualis—florets all ☿. 2. Polygamia superflua—florets of the disk ☿, those of the ray ♀, but fertile. 3. Polygamia frustranea—florets of the disk ☿, those of the ray abortive. 4. Polygamia necessaria—florets of the disk ♂, those of the ray ♀, and fertile. 5. Polygamia segregata—each flower with a separate involucre.
With the pistil on a column	XX. Gynandria	Monandria .... 1 stamen. Diandria .... 2 stamens. And so on, as in the first 13 classes.
II. Stamens and pistils in separate flowers—		
On the same plant	XXI. Monœcia	Monandria .... 1 stamen. Diandria .... 2 stamens. Hexandria .... 6 stamens. Polyandria .... numerous stamens. And so on, as in the first 13 classes. Monadelphia... stamens monadelphous.
On separate plants	XXII. Diœcia	
III. Stamens and pistils in the same and in separate flowers on the same or on separate plants	XXIII. Polygamia	1. Monœcia, ☿, ♂, ♀, on the same plant. 2. Diœcia, ☿, ♂, ♀, on 2 plants. 3. Triœcia, ☿, ♂, ♀, on 3 plants.

B. FLOWERLESS PLANTS.

Organs of reproduction inconspicuous	XXIV. Cryptogamia	1. Filices .... Ferns. 2. Musci .... Mosses. 3. Hepaticæ.............. Liverworts. 4. Lichenes .... Lichens. 5. Algæ..................... Seaweeds. 6. Fungi .... Mushrooms.

ANALYTICAL SYSTEM.

Not satisfied with the Linnæan system as a key to ascertaining the name of an unknown plant, Lamarck proposed another means for arriving at the same end. This he proposed to do by what is termed the Analytical or Dichotomous System, in which all plants are first of all divided into two groups by some one characteristic—say the possession of flowers. Well, the plant under examination either has or has not this character. If it has it will belong to the one division, if it has not it will belong to the other, and so on, dividing and sub-dividing, till at last the name of the plant is found out. This system differs from all others in selecting its character from any part of the plant indifferently, the grand object aimed at being not uniformity of method, but unmistakeable results. Those who wish to make themselves acquainted with the working of this system are referred to that excellent work, Bentham's "Handbook of the British Flora," where the scheme is set forth in all its details.

To the beginner such a scheme is invaluable; but though, comparatively speaking, little knowledge of Botany is required to work it, still that little must be accurate, otherwise the student will be continually arriving at wrong results, as there is nothing to serve as correctives to errors committed.

THE NATURAL SYSTEM.

The natural system of classification in Botany is an attempt to arrange all plants, so that those most closely related may be brought closest together, and to place every vegetable in its proper position in the scale of existence. To do so, it is plain that every plant should be known and its structure fully understood; but as we are far from possessing such a knowledge, any and all plans of arrangement hitherto adopted must be looked upon as only attempts at the solution of the great problem. It is also evident that some characters must have more *weight* than others, as being drawn from organs of greater *importance* in the vegetable economy, and therefore more universal in their presence. As the primary function in all living beings is nutrition, the most general characters, it is evident, will be drawn from the nutritive organs. The next most general function is reproduction, and the characters drawn from the organs set aside for its performance will be of corresponding importance. But as the organs set aside for the vegetative functions are extremely simple, while those set aside for reproduction are excessively varied, divisions founded on the characteristics furnished by the latter are more common than those provided by the former. The relative importance of the grounds on which plants are collected into groups is indicated below:

Species—Founded on peculiarities of vegetative organs, as leaves.

Genera—On the floral envelopes, and the external characters of the fruit.

Orders—On the structure of the ovary, and its relations to the floral envelopes.

Classes—On peculiarities of the seed, and especially of the Embryo.

The groups thus formed have not that precision and exactness of outline seen in Linnæus's system; and in all cases there must be a certain degree of artificiality mixed up with any natural system, seeing that in nature one group merges into another by almost insensible gradations, so that it is difficult to say where one division ends and another begins, except some arbitrary line be fixed on as the boundary.

Even before the time of Linnæus, attempts at a natural classification of plants had been made by our countryman Ray; and Linnæus himself left, in his "Fragments," the outlines of some natural groups. The first, however, who succeeded in making anything like a satisfactory grouping of the vegetable world was Jussieu, in 1789, who divided all plants into the three grand groups of Acotyledons, Monocotyledons, and Dicotyledons, subdividing the two latter according to the *cohesion of the corolla* and the *insertion of the stamens.* His orders were so satisfactory that, with few changes, they are retained at the present day.

In 1813, A. P. De Candolle made known his system,

genæ into Thalamifloræ, Calycifloræ, Corollifl
Monochlamydeæ, is still adhered to, though his
ment of the Endogenæ has been departed from.

The next great systematist was Endlicher, who
1836 and 1840 published his "Genera Plantar
ranged on a new basis. All plants were by him
into two grand divisions—Thallophyta, or such
no distinction between stem and leaf; and Corn
comprehending all plants with a distinct a
latter being subdivided into groups correspondi
the higher Cryptogamia, the Monocotyledons,
Dicotyledons.

Following in Endlicher's footsteps, Lindley p
a "Classification of the Vegetable Kingdom"
which was, however, considerably modified be
appearance of his "Vegetable Kingdom," in 1
this last publication he recognises two great div
plants—the Flowerless and the Flowering pla
former being subdivided into *Thallogens*, where
is visible, and *Acrogens*, where stem and leaves
tinct.

Flowering plants were by him divided into—

1. Rhizogens: where the fructification ap
   spring from a thallus.

   Ex. *Rafflesiaceæ*.

4. **Exogens**: Cotyledons double, leaves netted-veined; wood oldest at the centre; seeds covered.

Ex. *Leguminosæ*.

5. **Gymnogens**: Cotyledons double, leaves netted-veined; wood oldest at the centre; seeds naked.

Ex. *Pines*.

In most botanical text-books the classification adopted a modification of that of De Candolle, altered so as to it the more advanced knowledge of the period.
In describing the various natural orders, the practice De Candolle is most commonly followed in beginning ith the Thalamifloræ.

VEGETABILIA.

PHANEROGAMIA	CRYPTOGAMIA
Produce flowers and seeds, the latter containing an embryo.	Produce no flowers, but reproduce by spores which contain no embryo.

Phanerogamia.
- I. Exogenæ or Dicotyledons. Stems exogenous; leaves netted-veined; embryo di-, rarely poly-cotyledonous; roots exorhizal.
  - I. Angiospermia, seeds covered.
    - 1. Thalamifloræ. Corolla polypetalous; stamens hypogynous.
    - 2. Calycifloræ. Corolla usually polypetalous inserted on the calyx; stamens perigynous or epigynous.
    - 3. Corollifloræ. Corolla gamopetalous, and stamens epipetalous.
    - 4. Monochlamydeæ. Flowers with calyx only, or without calyx and corolla.
  - II. Gymnospermia, seeds naked.
- II. Endogenæ or Monocotyledons. Stem endogenous; leaves straight veined; embryo monocotyledonous; roots endorhizal.
  - 1. Spadicifloræ. Flowers on a spadix, and usually enclosed in a sheath (spathe).
  - 2. Petaloideæ. Flowers usually with calyx and corolla, both coloured, both green, or the outer green, the inner coloured.
  - 3. Glumiferæ. Floral envelopes in the form of membranous scales.

Cryptogamia.
- 1. Acrogenæ, with a distinct stem and leaves.
- 2. Thallogenæ, stem and leaves indistinguishable.

CLASSIFICATION.

SUB-KINGDOM I.

PHANEROGAMIA, OR FLOWERING PLANTS.

PLANTS having flowers (at least stamens and pistils), and producing seeds containing an embryo.

CLASS I.

EXOGENÆ, OR DICOTYLEDONS.

Stem consisting of a distinct bark and pith, separated by interposed woody layers, oldest towards the interior. Leaves articulated to the stem and netted-veined. Sepals and petals, when present, in fives or fours, rarely in threes. Embryo with two (rarely more) seed lobes. Tap-root developed from the Radicle.

DIVISION I.

Angiospermia.

Ovules produced in a closed ovary. Embryo with two cotyledons.

SUB-CLASS I.—*Thalamifloræ.*

Dicotyledons with calyx and corolla; the latter composed of distinct petals inserted on the receptacle. Stamens *hypogynous,* or inserted on the side of the ovary.

FIG. 303.

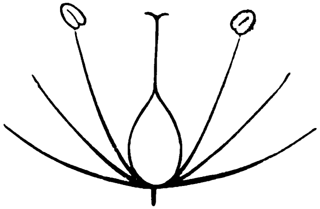


Diagram of Thalamifloræ.

ORDER 1.—*Ranunculaceæ—Crowfoot Family.*

Type, S_5 P_5 St_∞ C_∞
i.e, sepals 5, petals 5, stamens numerous or indefinite, pistils numerous or indefinite (∞ = indefinite.)*

Herbs, rarely shrubs, with watery acrid juice, no distinct stipules; æstivation usually imbricated; seeds solitary, albuminous, without an arillus, albumen horny.

SUB-ORDERS.

1. Clematideæ, calyx valvate or induplicate.
2. Anemoneæ, calyx coloured imbricate—seed inverted.
3. Ranunculeæ, calyx imbricate—seed erect. } Fruit achenes.
4. Helleboreæ, calyx imbricate, fruit follicles.
5. Acteæ (Lindley), calyx coloured imbricate, fruit berries.

Habitat, cold or temperate climates.—Properties, acrid.

OFFICINAL PLANTS.

Aconitum Napellus (aconite),—leaves and flowering tops, and root—officinal.—Active principle Aconitia. Sedative and anodyne. Dangerous poison.

---

* The symbols employed in these types or schedules are the ordinary symbol ∞ for indefinite, indicating that the number is greater than can be conveniently counted. A bracket (⌴) uniting the numbers indicative of stamens, petals, &c., indicates *adhesion* of these whorls. This will be placed below the line. A bracket or curve over a single whorl, sepals, petals, &c., indicates that the different parts of that whorl are more or less coherent. Two numbers with a plus + between indicate that there are two whorls each consisting of a given number. In Sach's Text-book a much more elaborate system of notation is explained and illustrated.

Podophyllum peltatum (Podophyllum or American May apple). Rhizome and Resin officinal. Drastic purgative.

FORMERLY OFFICINAL.

Helleborus Niger (Black Hellebore),—rhizome and root officinal. Drastic purgative.

Delphinium Staphisagria (Stavesacre). Seeds officinal. Local irritant.

OTHER PLANTS USEFUL OR DANGEROUS.

Aconitum ferox of India, used for preparing Aconitia. and the "Bikh" poison, very dangerous.

Actea or Cimicifuga racemosa, root used extensively in America in treatment of rheumatism.

Coptis trifoliata and Hydrastis Canadensis, roots used as tonics in America.

Various species of Clematis and Ranunculus are dangerous poisons.

ORDER 2.—*Magnoliaceæ—Magnolia Family.*

Habitat, chiefly North America.—Properties, bitter tonic.

OFFICINAL.

Illicium anisatum (Star—Anise); fruit used for preparing Oleum Anisi.

FORMERLY OFFICINAL.

Drymis Winteri (Winter's Bark tree); bark aromatic and tonic.

The bark of Magnolia glauca (Swamp sassafras) and Liriodendron tulipifera (Tulip tree) are somewhat tonic, and have been used in medicine.

ORDER 3.—*Menispermaceæ—Moon-seed Order.*

Habitat, tropical.—Properties, bitter and narcotico-acrid.

OFFICINAL.

Cocculus palmatus (Calumbo); root officinal. Extensively used as a tonic.

Cissampelos Pareira (Pareira); root officinal. Astringent, diuretic (?), and sedative to the bladder.

Anamirta or Menispermum Cocculus (Cocculus Indicus). Fruit officinal. Active principle Picrotoxine. Used for destroying parasites, and killing fish.

ORDER 4.—*Berberidaceæ—Berberry Family.*

Type, S_{3+3} P_{2+3} St_{3+3} C

Herbs or shrubs. Leaves often spiny, usually exstipulate; flowers regular and symmetrical, with trimerous symmetry; stamens sometimes irritable; anthers opening by recurved valves; seeds 2 or 3, albuminous.

Habitat, temperate climates.—Properties, acid and astringent. Ex. *Berberis.*

ORDER 5.—*Nymphæaceæ—Water Lily Family.*

Type, S_4 P_∞ St_∞ C_∞

Aquatic herbs with large floating leaves, rising from a rhizome. Thalamus large; ovary compound, with radiating stigma; dissepimental placentæ; seeds indefinite; albumen copious.

Habitat, mostly in N. hemisphere.—Properties, slightly bitter and astringent.

Ex. *Nymphæa and Nuphar.*

ORDER 6.—*Papaveraceæ—Poppy Family.*

Type, S_2 P_2 St_∞ $C_{\widehat{\infty}}$

Herbs with a milky juice. Leaves exstipulate; sepals two, rarely three, caducous; ovary one-celled; placentæ parietal; seeds indefinite, albuminous.

Ex. *Papaver.*

Habitat, mostly European.—Properties, narcotic.

OFFICINAL.

Papaver somniferum (Garden poppy). Capsules, and *Opium*, their concrete juice, officinal. The principal active agent is Morphia. Stimulant in small doses, narcotic in large.

Papaver Rhæas (common Poppy). Petals officinal.—Colouring agent; slightly narcotic.

NOT OFFICINAL.

Chelidonium majus and Sanguinaria Canadensis are more or less irritant. Argemone Mexicana, seeds narcotico-acrid.

ORDER 7.—*Fumariaceæ—Fumitory Family.*

Type, S_2 P_4 $St_{\widehat{3}+\widehat{3}}$ C_2

Smooth herbs with watery juice. Leaves much divided, exstipulate; flowers irregular; sepals two, deciduous; stamens six, diadelphous, opposite the petals; seeds albuminous; embryo small.

Ex. *Fumaria—Dicentra.*

Habitat, northern temperate climates.—Properties unimportant.

ORDER 8.—*Cruciferæ (Brassicaceæ)—Cabbage Family.*

Type, S_4 P_4 St_6 $C_{\widehat{2}}$

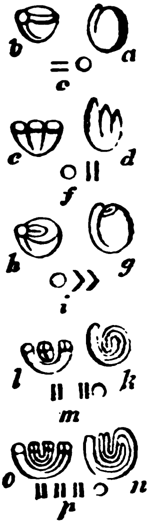
Herbs, rarely shrubs. Leaves alternate, exstipulate; flowers in corymbs, often becoming racemes, and without bracts; sepals four, deciduous; four petals in the form of a cross; six stamens, four long and two short (tetradynamous); ovary two-celled, with spurious dissepiment (replum) in the form of *siliqua* or *silicula;* seeds exalbuminous; embryo folded.

Ex. *Cabbage, Mustard, Wallflower, &c.*

The Cruciferæ are divided into suborders on two distinct plans—the one founded on the nature of the fruit, the other on the structure of the seed. When divided according to the nature of the fruit, the following are the subdivisions:—

1. Siliquosæ—fruit a siliqua.
2. Siliculosæ—fruit a silicula.
    - *α.* Latiseptæ, replum stretching across the long diameter.
    - *β.* Angustiseptæ, replum stretching across the short diameter.

3. Nucumentaceæ, fruit an indehiscent silicula, often without a replum.
4. Septulatæ. valves bearing transverse dissepiments.
5. Lomentaceæ, fruit a pod with false septa, constricted at intervals, and breaking at these dissepiments.



a, A seed with an accumbent radicle, one of the *Pleurorhizeæ.* *b*, A transverse section of the same, to show the radicle applied to the edges of the two cotyledons. *c*, The symbol by which such a position is indicated, the circle representing the cut radicle, and the two parallel lines the two cotyledons. *d*, A seed showing the radicle incumbent or folded on the back of the cotyledons, which in this instance are plane, it being one of the *Notorhizeæ.* *e*, Transverse section of the same. *f*, The symbol by which it is represented, the circle as before indicating the radicle, and the two parallel lines the two cotyledons. *g*, A seed with incumbent radicle and straightly folded cotyledons, one of the *Orthoploceæ.* *h*, A transverse section of the same. *i*, The symbol by which this form is represented, the circle indicating the radicle, and the angular lines the bent cotyledons. *k*, A seed with incumbent radicle, and circinate or spirally folded cotyledons; one of the *Spirolobeæ.* *l*, A transverse section. *m*, The symbol by which this form is represented, the circle indicating the radicle, and the two sets of parallel lines the cotyledons, which are twice cut through. *n*, A seed with an incumbent radicle and doubly folded cotyledons, one of the *Diplecolobeæ.* *o*, A transverse section of the same. *p*, The symbol by which this form is represented; the circle indicating the radicle cut across, and the three pairs of parallel lines the cotyledons, which in the section are thrice divided.

The other mode of subdivision founded on the ovules was introduced by De Candolle, and is that more generally adopted (Fig. 303).

1. Pleurorhizeæ—cotyledons accumbent, radicle lateral, symbol (O =).
2. Notorhizeæ—cotyledons incumbent, radicle dorsal, symbol (O ||).
3. Orthoploceæ—cotyledons conduplicate enclosing the dorsal radicle, symbol (O ≫).

4. Spirolobeæ—cotyledons twice folded, linear incumbent, symbol (O || ||).
5. Diplecolobeæ—cotyledons thrice folded, linear incumbent, symbol (O || || ||).

Habitat, temperate climates.—Properties, pleasantly bitter.

OFFICINAL.

Sinapis alba and nigra (White and Black Mustard), powdered seeds used. Acrid volatile oil, produced by contact with water. Stimulant and emetic.

Cochlearia Armoracia (Horseradish), root used. Stimulant.

NON-OFFICINAL.

Nasturtium officinale (Watercress); Cochleare officinalis (Scurvy grass); Lepidum sativum (garden cress); Crambe Maritima (Sea Kale); Raphanus sativus (common radish); Brassica rapa (turnip), and Brassica oleracea (cabbage), are all well known as articles of food. Isatis tinctoria, the woad plant, was used for its blue dye before the introduction of indigo. All Crucifers are wholesome as food.

ORDER 9.—*Resedaceæ—Mignonette Family.*

Type, $S_{4 \text{ or } 6}$ $P_{4 \text{ or } 6}$ St_{∞} $C_{\overset{\frown}{3}}$

Herbs.—Petals 4—6, unequal and laciniated; stamens indefinite, inserted on a lateral disc; ovary one-celled; placentæ parietal; seeds numerous, reniform, exalbuminous.

Ex. *Reseda*—Common Mignonette.

Habitat, European.—Properties not well known.

ORDER 10.—*Cistaceæ—Rock-rose Family.*

Type, S_5 P_5 St_{∞} $C_{\overset{\frown}{3}}$

Herbs or low shrubs. Flowers regular; sepals usually 5; stamens indefinite; seeds albuminous; embryo curved.

Ex. *Cistus; Helianthemum.*

Habitat, S. Europe, and N. Africa.—Properties unimportant.

ORDER 11.—*Violaceæ—Violet Family.*

Type, S_5 P_5 St_5 $C_{\overset{\frown}{3}}$

Herbs or shrubs; flowers irregular; anthers crested and introrse, connection being prolonged beyond the anther cells; ovary one-celled; placentæ parietal; seeds numerous, albuminous.

Ex. *Viola.*

Habitat, temperate climates chiefly.—Properties, purgative and emetic.

FORMERLY OFFICINAL.

Viola odorata, leaves used for colouring.

Ionidium yields a kind of ipecacuanha.

ORDER 12.—*Caryophyllaceæ—Pink Family.*

Type, S_5 P_5 St_{10} C_3

Herbs, with stems swollen at the joints; leaves opposite, entire, exstipulate; flowers regular; symmetry 4- or 5-merous; ovary one-celled; placenta central; embryo curved round albumen.

Ex. *Alsine, Silene.*

Sub-orders.—1. Alsineæ, Calyx polysepalous.
„ 2. Sileneæ, Calyx gamosepalous.

Habitat, cold and temperate climates.—Properties unimportant; flowers showy.

ORDER 13.—*Malvaceæ—Mallow Family.*

Type, $S_{\overset{\frown}{5}}$ $P_{5 \text{ or } \overset{\frown}{5}}$ $St_{\overset{\frown}{\infty}}$ $C_{\overset{\frown}{\infty}}$

Herbs or shrubs; leaves alternate and stipulate; flowers regular; calyx valvate; corolla contorted; stamens monadelphous; anthers one-celled; seeds little or no albumen; embryo curved.

Ex. *Althœa, Gossypium.*

Habitat, chiefly tropical and subtropical.—Properties, mucilaginous.

OFFICINAL.

Gossypium; seeds yield cotton used in preparing collodion.

FORMERLY OFFICINAL.

Althæa officinalis (Marsh-mallow); root demulcent. Other species of Althæa and Malva are demulcent. Hibiscus yields hemp, Gossypium cotton.

Order 14.—*Tiliaceæ—Lime or Linden Family,*

Type, S_5 P_5 St_∞ $P_{\overset{\frown}{5}}$

Trees or shrubs; leaves stipulate; calyx valvate; corolla imbricate; sepals deciduous; stamens polyadelphous, anthers two-celled. Distinguished from the three last by polyadelphous stamens, and two-celled anthers.

Ex. *Tilia.*

Habitat, few northern, chiefly tropical.—Properties, demulcent.

Tilia Europæa yields the "bast" for making mats.

Corchorus Capsularis yields "jute."

Order 15.—*Guttiferæ, or Clusiaceæ—Gamboge Family.*

Trees or shrubs with resinous juice.

Ex. *Garcinia.*

Habitat, tropical or moist regions.—Properties, juice purgative.

OFFICINAL.

Garcinia and Hebradendron—concrete juice constitutes Gamboge, a drastic cathartic. Various others yield resinous substances.

Order 16.—*Hypericaceæ—St. John's-wort Family.*

Type, S_5 P_5 St_∞ $C_{\overset{\frown}{3}}$

Herbs or shrubs; leaves opposite, exstipulate; flowers regular; stamens polyadelphous; ovary usually one-celled, with central placentæ; seeds numerous, exalbuminous. Ex. *Hypericum.*

Habitat, generally distributed.—Properties of no importance.

ORDER 17.—*Polygalaceæ—Milk-wort Family.*

Type, S_5 P_3 $St_{\overset{\frown}{8}}$ $C_{\overset{\frown}{2}}$

Herbs or shrubs; leaves exstipulate; flowers irregular and unsymmetrical, but complete; petals usually falsely papilionaceous, but odd petal anterior; anthers one-celled, with porous dehiscence; seeds albuminous.

Ex. *Polygala and Krameria.*

Habitat, generally distributed.—Properties bitter and astringent.

OFFICINAL.

Polygala Senega (Senega), rhizome officinal; stimulant, expectorant.

Krameria Triandra (Rhatany), root employed, excellent astringent.

ORDER 18.—*Aurantiaceæ—Orange Family.*

Trees or shrubs; leaves smooth and jointed to the petiole; flowers regular; stamens slightly coherent; ovary many-celled; fruit pulpy, with leathery rind; seeds exalbuminous. Ex. *Citrus, Ægle.*

Habitat, the warmer climates.—Properties, acid, refrigerant.

OFFICINAL.

Citrus Aurantium (sweet orange), flowers officinal. Aromatic, and stimulant.

Citrus Bigaradia (bitter orange), flowers and fruit officinal. Aromatic and stimulant.

Citrus Limonum (lemon), rind, juice, and volatile oil officinal. Stimulant and antiscorbutic.

Ægle Marmelos (bael), rind of unripe fruit officinal. Astringent.

ORDER 19.—*Linaceæ—Flax Family.*

Type, S_5 P_5 St_5 $C_{\overset{\frown}{5}}$

Herbs or slender shrubs, without stipules; flowers [illegible]*egular*; sepals imbricate; petals contorted; stamens [illegible]*erent* at the base; ovary many-celled, each cell being divided into two by a false septum, and each division containing a single exalbuminous seed, with a large quantity of oil in the embryo.

Ex. *Linum.*

Habitat, generally diffused.—Properties vary.

OFFICINAL.

Linum Usitatissimum (flax),—seeds and oil;—demulcent.

FORMERLY OFFICINAL.

Linum catharticum (purging flax),—stalks;—purgative.

ORDER 20.—*Geraniaceæ—Crane's-bill Family.*

Type, S_5 P_5 $St_{\widehat{10}}$ $C_{\overset{\frown}{5}}$

Herbs, or shrubs with swollen joints; leaves stipulate; flowers usually regular; sepals imbricate; petals contorted; stamens monadelphous; carpels and styles adherent to an elongated torus (Carpophore), from which they separate when ripe.

Ex. *Geranium; Pelargonium (irregular).*

Habitat, temperate climates.—Properties, slightly astringent and aromatic.

ORDER 21.—*Zygophyllaceæ—Bean-caper Family.*

Ex. *Guaiacum.*

Habitat, subtropical.—Properties, stimulant and diaphoretic.

OFFICINAL.

Guaiacum officinale (Guaiacum),—wood and resin,—stimulant and diaphoretic.

ORDER 22.—*Rutaceæ—Rue Family.*

Herbs, shrubs, or trees; leaves dotted, exstipulate; flowers perfect; ovules sessile; seeds usually albuminous; radicle superior. Ex. *Ruta.*

Habitat, S. of temperate zone.—Properties, varied, mostly tonic.

OFFICINAL.

Ruta Graveolens (Rue), oil,—stimulant and emmenagogue.

Barosma { betulina, serratifolia, crenulata } (Buchu); leaves—tonic and astringent to bladder.

Galipea Cusparia (Angustura Bark), bark,—tonic and febrifuge.

ORDER 23.—*Simarubaceæ—Quassia Family.*

Habitat, tropical.—Properties, tonic and febrifuge.

Ex. *Picræna; Simaruba.*

OFFICINAL.

Picræna excelsa (Quassia),—wood,—tonic.

FORMERLY OFFICINAL.

Simaruba amara,—bark,—tonic.

Simaba Cedron,—seeds,—tonic.

ORDER 24.—*Vitaceæ—Vine Family.*

Shrubs, usually climbing by tendrils; limb of calyx nearly obsolete; petals valvate and opposite the stamens; seeds bony, albuminous.

Ex. *Vitis.*

OFFICINAL.

Vitis vinifera (vine),—fruit or uvæ (raisins),—sweetening agent; also yields sherry (Vinum Xericum), the officinal wine.

SUB-CLASS II.

Calyciflorœ.

Flowers usually with calyx and corolla; petals distinct or united, inserted on the calyx; stamens perigynous or epigynous.

FIG. 305.

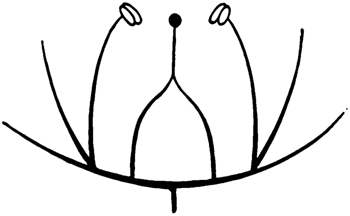


Diagram of Calycifloræ.

The characters of this sub-class are extremely artificial, causing the breaking up of natural groups, and the location of their fragments in different sub-classes.

ORDER 25.—*Celastraceœ—Spindle-tree Family.*

Type, S_4 P_4 St_4 $C_{\overset{\frown}{4}}$

Shrubs with simple leaves, having small deciduous stipules; flowers regular; æstivation imbricate; stamens alternate with the petals; seeds usually arillate, albuminous. Ex. *Euonymus; Celastrus.*

Habitat, subtropical.—Properties, more or less acrid.

ORDER 26.—*Rhamnaceœ—Buckthorn Family.*

Small trees or shrubs; leaves simple; flowers small; calyx valvate; stamens opposite the petals; seeds albuminous and without an arillus.

Ex. *Rhamnus; Zizyphus.*

Habitat, generally diffused.—Properties, varied, chiefly purgative.

FORMERLY OFFICINAL.

Rhamnus catharticus (Buckthorn),—juice of berries,—purgative.

Order 27.—*Anacardiaceæ—Cashew-nut Family.*

Trees with resinous, milky juice; leaves exstipulate; flowers often diœcious or polygamous; ovary one-celled; ovules solitary, with long funiculus; fruit indehiscent; seeds albuminous.

Ex. *Pistacia; Rhus.*

Habitat, tropical.—Properties, acrid and stimulant.

OFFICINAL.

Pistacia Lentiscus (Mastic),—resinous exudation from the tree,—slightly stimulant.

FORMERLY OFFICINAL.

Pistacia Terebinthus (Chian Turpentine),—oleo-resinous exudation,—stimulant.

Rhus Toxicodendron (Poisoned Sumach), leaves irritant, &c.

Order 28.—*Amyridaceæ—Frankincense Family.*

Trees or shrubs with resinous juice; flowers generally perfect. Ex. *Balsamodendron, &c.*

Habitat, tropical.—Properties, stimulant.

OFFICINAL.

Balsamodendron Myrrha (Myrrh),—gum-resinous exudation,—stimulant.

Canarium Commune (Elemi),—gum-resinous exudation,—stimulant.

FORMERLY OFFICINAL.

Boswellia Serrata (Olibanum),—gum-resinous exudation,—stimulant, but chiefly used for incense.

The two last groups, with some other plants, were comprehended in the old Terebinthaceæ.

ORDER 29.—*Leguminosæ* (*Fabaceæ*)—*Pea Family.*

Type, $\underline{\,|\; S_{\overset{\frown}{5}} \quad P_5 \quad St_{\overset{\frown}{9}} + 1 \;|\,} \quad C_1$

Herbs, shrubs, and trees, with alternate, stipulate leaves, often compound; flowers mostly papilionaceous; stamens usually mon- or di-adelphous; simple pistil, becoming a legume or lomentum, rarely a drupe; seeds exalbuminous; odd sepal anterior.

Ex. *Pisum; Cassia, &c.*

Habitat, generally distributed.—Properties very varied.

SUB-ORDERS.

I. Papilioneæ: flowers papilionaceous; vexillum (odd petal) external in imbricate æstivation.

II. Cæsalpineæ: corolla imbricated; odd petal internal.

III. Mimoseæ: corolla valvate; flowers regular.

OFFICINAL PLANTS.

I. *Papilioneæ.*

Glycyrrhiza glabra (Liquorice)—root,—sweetening demulcent.

Astragalus verus (Tragacanth),—gummy exudation,—demulcent.

Sarothamnus Scoparius (Broom),—flowering tops,—diuretic.

Pterocarpus Santalinus (Sandal-wood),—wood,—red colouring agent.

Pterocarpus $\left\{\begin{array}{l}\text{Marsupium}\\ \text{Erinaceus}\end{array}\right\}$ (Kino),—hardened juice, —astringent.

Myrospermum Pereiræ (Balsam of Peru),—balsam flowing from tree,—stimulant.

Myrospermum Toluiferum (Balsam of Tolu),—balsam from tree,—stimulant and expectorant.

FORMERLY OFFICINAL.

Mucuna pruriens (Cowitch),—hairs of pods,—used as vermifuge.

Physostigma venenosum (Calabar bean),—mydriatic.

II. *Cæsalpinieæ.*

OFFICINAL.

Hæmatoxylon Campechianum (Logwood),—wood,—astringent.

Cassia	elongata,	Tinnevelly senna,	leaves,—purgative.
	obovata, lanceolata,	Alexandrian senna,	

Cassia fistula (Cassia),—pulp,—laxative.
Tamarindus Indica (Tamarind),—pulp,—laxative.
Copaifera multijuga (Copaiba),—oleo-resinous exudation and oil,—stimulant, expectorant, &c.

III. *Mimoseæ.*

Acacia (Gum Arabic),—gummy exudation,—demulcent.
Acacia Catechu (Catechu),—extract from wood,—astringent.

Besides these, many other plants belonging to this Order are employed in the arts, as medicines, or as food.

Order 30.—*Rosaceæ—Rose Family.*

Type, $|\underline{S_{\overset{\frown}{5}}\quad P_5\quad St_\infty}|\quad C_\infty$

Herbs, shrubs, or trees; leaves usually stipulate; flowers regular; stamens distinct, perigynous; ovaries free or coherent; ovules one or few; styles often lateral; seeds exalbuminous; embryo straight.

Ex. *Rosa—Prunus.*

Habitat, universally distributed.—Properties, very varied.

SUB-ORDERS.

Drupaceæ.
I. Chrysobalaneæ: trees or shrubs with free stipules; style basilar; fruit a drupe; seed erect.
II. Amygdaleæ: trees or shrubs with free stipules; style terminal; fruit a drupe; seed ascending.

III. Pomeæ: stipules free; styles terminal; seeds ascending.

IV. Roseæ: stipules adnate; styles lateral; fruit an etærio, or several follicles; seeds usually suspended.

V. Sanguisorbeæ: apetalous, often diclinous; style terminal or lateral; fruit an achene, surrounded by the calyx tube; one-seeded.

OFFICINAL.

Rosa centifolia (Cabbage rose),—petals,—(rose-water as a vehicle).

Rosa Gallica (Red rose),—petals,—colouring agent, astringent, vehicle.

Rosa canina (Dog rose),—hips,—slight refrigerant, and pill-base.

Amygdalus communis (sweet and bitter almonds),—fruit and oil; fruit of sweet only used. Bitter contain amygdaline and emulsine, which form Prussic acid in the presence of water.

Prunus domestica (Prune),—fruit,—sweetening, laxative.

Prunus Lauro-cerasus (Cherry laurel)—leaves by distillation yield Prussic acid; used as a sedative and anodyne.

Brayera anthelmintica (Kousso),—flowers,—anthelmintic.

FORMERLY OFFICINAL.

Potentilla Tormentilla (Tormentil),—rootstock,—astringent.

Cydonia vulgaris (Quince),—seeds,—demulcent.

ORDER 31.—*Myrtaceæ—Myrtle Family.*

Aromatic trees or shrubs.

Ex. *Melaleuca; Pimenta.*

Habitat, tropical and subtropical.—Properties, warm, aromatic, stimulant.

OFFICINAL.

Caryophyllus aromaticus (Clove),—unexpanded flower, bud and oil,—aromatic, stimulant.

Eugenia Pimenta (Allspice),—unripe fruit and oil;—aromatic, stimulant.

Melaleuca minor (Cajeput),—oil distilled from the leaves;—aromatic, stimulant.

Eucalyptus resinifera (Botany Bay kino),—hardened juice,—astringent.

Punica Granatum (pomegranate),—bark of root (fresh), —anthelmintic.

ORDER 32.—*Lythraceæ.*

Herbs, shrubs, or trees, with opposite, exstipulate leaves; calyx surrounding the ovary, but free from it; styles united. Ex. *Lythrum.*

Habitat, tropical.—Properties, unimportant.

ORDER 33.—*Onagraceæ—Evening Primrose Family.*

Type, $\underline{|\, S_{\overset{\frown}{4}} \quad P_4 \quad St_8 \,|} \qquad C_{\overset{\frown}{4}}$

Herbs or shrubs; leaves without dots or stipules; symmetry 4-merous; calyx adherent to ovary; fruit capsular; seeds numerous, exalbuminous.

Ex *Epilobium; Fuchsia.*

Habitat, temperate climates.—Properties, harmless.

ORDER 34.—*Saxifragaceæ—Saxifrage Family.*

Type, $\underline{|\, S_{\overset{\frown}{5}} \quad P_5 \quad St_{10} \,|} \qquad C_{\overset{\frown}{2}}$

Herbs with alternate leaves; ovaries usually united below, and distinct above; seeds numerous and small, with fleshy albumen.

Ex. *Saxifraga; Hydrangea.*

Habitat, northern climates.—Properties, unimportant.

To this group also belong Drosera and Dionæa, examples of carnivorous plants.

ORDER 35.—*Crassulaceæ—Stone-crop Family.*

Type, $\underline{|\, S_{\overset{\frown}{5}} \quad P_5 \quad St_{10} \,|} \qquad C_{\overset{\frown}{5}}$

Herbs with succulent leaves, and symmetrical flowers; carpels more or less coherent; seeds small, albuminous.

Ex. *Sedum; Bryophyllum.*

Habitat, generally diffused.—Properties, mostly unimportant, somewhat acrid.

Order 36.—*Cucurbitaceæ—Gourd Family.*

Male . . ♂ $\underline{S_{\overset{\frown}{5}} \quad P_{\overset{\frown}{5}} \quad St_{3}} \quad C_{0}$

Female . ♀ $\underline{S_{\overset{\frown}{5}} \quad P_{5} \quad St_{0}} \quad C_{\overset{\frown}{3}}$

Herbaceous plants, mostly succulent, climbing by tendrils; flowers declinous; calyx tube adhering to ovary; stamens sometimes partially united; anthers sinuous; ovary inferior; placentæ fleshy; seeds exalbuminous.

Ex. *Cucumis; Ecbalium.*

Habitat, chiefly in hot climates.—Properties, mostly purgative.

OFFICINAL.

Citrullus (Cucumis) Colocynthis (Colocynth),—pulp of dried fruit;—purgative.

Ecbalium Officinarum (Elaterium),—sediment from juice of fruit;—purgative.

Order 37.—*Ribesiaceæ, or Grossulariaceæ—Currant Family.*

Type, $\underline{S_{\overset{\frown}{5}} \quad P_{5} \quad St_{5}} \quad C_{\overset{\frown}{2}}$

Small shrubs, with or without spines or prickles; leaves alternate; calyx superior; ovary inferior, one-celled; fruit pulpy; seeds numerous, albuminous, parietal.

Ex. *Ribes.*

Habitat, temperate climates.—Properties, agreeably acid.

Order 38.—*Umbelliferæ (Apiaceæ)—Parsley Family.*

Type, $\underline{S_{\overset{\frown}{5}} \quad P_{5} \quad St_{5}} \quad C_{\overset{\frown}{2}}$

Herbs, usually with hollow stems; leaves much cut up, and sheathing at the base; flowers in umbels; calyx superior; petals inflexed at the point, and along with the stamens inserted on an epigynous disc; fruit, a cremocarp, separating, when ripe, into two parts, or mericarps, supported on a carpophore, marked by vittæ; seeds solitary, pendulous, albuminous.

Ex. *Conium; Œnanthe.*

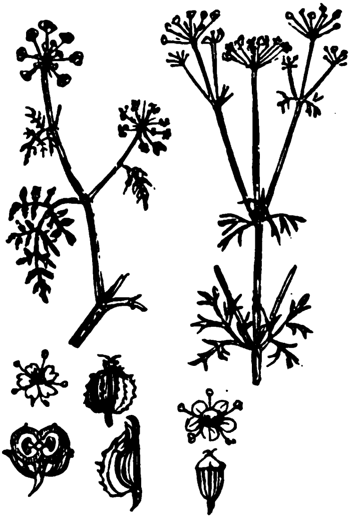
Habitat, N. temperate zone.—Properties, very varied.

OFFICINAL.

Conium maculatum (Hemlock),—fresh leaves and branches, and ripe fruit (act. prin., Conia);—sedative, dangerous poison.

Narthex Assafœtida (Assafœtida),—gum-resinous juice of cut root,—stimulant and antispasmodic.

A Fig. 306. B



A, Conium maculatum. Cutting to show the leaves and inflorescence. *a*, A flower isolated, to show its five petals and five stamens. *b*, The fruit, consisting of two mericarps with their commissure, ridges, and persistent styles with epigynous disc. *c*, Transverse section of the fruit, showing the apposition of the mericarps, the embryo, and the laterally incurved albumen, the axis, and the commissure. *d*, Longitudinal section, showing the small embryo and superior radicle. *e*, The embryo isolated. B, Petroselinum sativum; cutting to show the foliage and inflorescence. *a*, A flower separated. *b*, The fruit, composed of two mericarps, and surmounted by the epigynous disc and persistent styles. *c*, The mericarps separated, showing the axis. *d*, Section of the albumen, to show its plane internal surface.

Galbanum officinale (?) (Galbanum),—gum resin (source unknown);—stimulant and antispasmodic.

Dorema Ammoniacum (Ammoniacum),—gum-resinous exudation from stem and pedicels; stimulant, expectorant.

Pimpinella Anisum (Aniseed),—oil distilled from fruit;—stimulant.

Fœniculum dulce (Sweet Fennel),—ripe fruit;—stimulant.

Coriandrum sativum (Coriander),—oil distilled from ripe fruit and fruit;—stimulant.

Carum Carui (Caraway),—fruit and oil distilled from it;—stimulant.

Anethum graveolens (Dill),—fruit and oil distilled from it;—stimulant.

FORMERLY OFFICINAL.

Sagapenum,—gum resin, source unknown;—stimulant.

Cuminum Cyminum (Cumin),—fruit;—stimulant.

The carrot (Daucus Carota), and musk root (Sumbul), are also used in medicine.

Many other plants belonging to this order are employed as food, or medicine, or are to be avoided as poisonous.

ORDER 39.—*Araliaceæ—Ivy Family.*

Type, $\underline{|\, S_{\overset{\frown}{5}} \quad P_{\overset{\frown}{5}} \quad St_{\overset{\frown}{5}} \,|} \quad C_{\overset{\frown}{5}}$

Closely allied to the preceding, but having an ovary composed of more than two carpels. In most the corolla is valvate, whilst it is usually imbricate in the Umbelliferæ. Ex. *Hedera.*

Habitat, universally distributed.—Properties, mostly aromatic and stimulant.

ORDER 40.—*Cornaceæ—Dogwood Family.*

Allied to Umbelliferæ, but distinguished by 4-merous symmetry, and opposite leaves; and to Araliaceæ, but have 2-carpellary ovary.

Ex. *Cornus; Aucuba.*

Habitat, temperate regions.—Properties, slightly tonic.

SUB-CLASS III.

Corolliflorœ.

Dicotyledons having both calyx and corolla, the latter gamopetalous, stamens mostly epipetalous, rarely free.

FIG. 307.

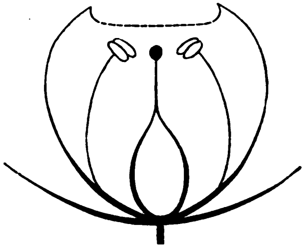


Diagram of Corolliflorœ.

Like the other divisions, very artificial. Some make its boundary line here; others elsewhere.

ORDER 41.—*Caprifoliaceœ*—*Honeysuckle Family.*

Type, $\underline{\mid S_{\overset{\frown}{5}} \quad \mid \underline{P_{\overset{\frown}{5}} \quad St_5} \mid \quad C_3 \mid}$

Shrubs, rarely herbs; leaves opposite, exstipulate; calyx persistent; corolla gamopetalous; ovary inferior; one style, with 3–5 stigmas; fruit indehiscent; seeds, with fleshy albumen.

Ex. *Lonicera; Sambucus.*

Habitat, N. regions.—Properties varied, but unimportant.

OFFICINAL.

Sambucus niger (Elder);—flowers yielding a volatile oil;—slight stimulant.

ORDER 42.—*Rubiaceœ*—*Madder Family.*

Type, $\underline{\mid S_{\overset{\frown}{4}} \quad \mid \underline{P_{\overset{\frown}{4}} \quad St_4} \mid \quad C_{\overset{\frown}{2}} \mid}$

Herbs, shrubs, or trees, with opposite, entire leaves, having large interposed stipules, or in true whorls; calyx adherent to the ovary; stamens equal in number to the lobes of the corolla, and alternate with them, inserted on the tube. Ex. *Galium; Cinchona.*

Habitat, partly temperate, partly tropical.—Properties, very varied.

SUB-ORDERS.

I. Galiaceæ or Stellatæ.—Herbs with the leaves in apparent whorls, but all except two are commonly held to be stipules.

II. Cinchonaceæ.—Herbs, shrubs, or trees; leaves opposite, with stipules of various forms.

OFFICINAL.

Rubiaceæ, None.

Cinchonaceæ.

Cinchona Calisaya (Yellow Bark),—Bark, (alk., chiefly Quinia)—tonic and antiperiodic.

Cinchona Condaminea (Pale or Crown Bark),—Bark, (alk., chiefly Cinchonia)—tonic and antiperiodic.

Cinchona Succirubra (Red Bark),—Bark, (alk., Quinia and Cinchonia), tonic and antiperiodic.

Cephaelis Ipecacuanha
Psychotria emetica } (Ipecacuanha),—Root, (active principle Emetina,)—emetic, expectorant, diaphoretic.

Uncaria Gambir (Pale Catechu),—extract from leaves,—astringent.

NON-OFFICINAL.

Coffea Arabica (Coffee),—berries yield coffee,—stimulant.

ORDER 43.—*Valerianaceæ—Valerian Family.*

Type, $\underline{\mid S_{\overset{\frown}{5}}\quad \underline{\mid P_{\overset{\frown}{5}}\quad St_3} \mid\quad C_3 \mid}$

Herbs. Leaves opposite, exstipulate; flowers often in capitula; tube of the calyx adherent to ovary, limb obsolete, or in the form of pappus; corolla tubular, sometimes spurred; stamens alternate with lobes of corolla, epipetalous; fruit sometimes pappose; seed solitary, exalbuminous.

Ex. *Valeriana; Centranthus.*

Habitat, N. temperate zone.—Properties, stimulant and antispasmodic.

OFFICINAL.

Valeriana officinalis (Valerian),—root,—(act. prin., Valerianic acid),—stimulant and antispasmodic.

ORDER 44.—*Dipsaceæ—Teazel Family.*

Type, $\underbrace{S_{\overset{\frown}{4}} \quad \underbrace{P_{\overset{\frown}{4}} \quad St_4} \quad C_{\overset{\frown}{2}}}$

Herbs. Leaves opposite or whorled, exstipulate; flowers in capitula with an involucre; calyx inferior, limb membranous or pappose; corolla tubular, limb somewhat irregular; stamens epipetalous; ovary one-celled; seeds solitary, pendulous, albuminous.

Ex. *Dipsacus; Scabiosa.*

Habitat, S. Europe, N. and S. Africa.—Properties, unimportant.

ORDER 45.—*Compositæ* (*Asteraceæ*)—*Composite Family.*

Type, $\underbrace{S_{\overset{\frown}{5}} \quad \underbrace{P_{\overset{\frown}{5}} \quad St_{\overset{\frown}{5}}} \quad C_{1 \text{ or } \overset{\frown}{2}}}$

Herbs or shrubs. Flowers in heads, surrounded by an involucre composed of bracts (phyllaries), and each floret by a secondary involucel of paleæ; calyx superior and limb pappose or obsolete; corolla tubular, labiate, or ligulate (strap-shaped); stamens epipetalous; anthers syngenesious; style bifid; ovary one-celled and one-seeded; fruit a cypsela; ovule erect; seed exalbuminous.

Ex. *Anthemis; Carduus; Lactuca.*

Habitat, universally distributed.—Properties, mostly bitter.

SUB-ORDER I.

1. Tubulifloræ. Florets tubular or ligulate, perfect, *unisexual* or neuter; includes the Corymbiferæ and *Cynarocephalæ* of Jussieu.

2. Labiatifloræ. Corolla bilabiate; florets perfect or unisexual. Unknown to Jussieu.

3. Liguliforæ. Corolla strap-shaped; florets perfect=Cichoraceæ of Jussieu.

OFFICINAL.

Artemisia Santonica (?) (Santonica),—unexpanded florets (active principle, santonin);—anthelmintic.

Anthemis nobilis (Chamomile),—flower heads and oil distilled from them,—tonic.

Taraxacum Dens Leonis (Dandelion),—rootstock,—alterative and slightly purgative.

Arnica montana (Arnica),—rootstock,—stimulant and irritant.

FORMERLY OFFICINAL.

Inula Helenium (Elecampane),—root,—stimulant.

Anacyclus Pyrethrum (Pellitory),—root,—stimulant and masticatory.

Artemisia absinthium (Wormwood),—whole plant,—stomachic and tonic.

Lactuca sativa (Garden lettuce) } Juice yields lactuca-
Lactuca virosa (Wild lettuce) } rium,—sedative.

ORDER 46.—*Lobeliaceæ—Lobelia Family.*

Herbs or shrubs with milky juice.

Ex. *Lobelia.*

Habitat, tropical and subtropical.—Properties, narcotico-acrid.

OFFICINAL.

Lobelia inflata (Lobelia),—whole plant (yields Lobelina,)—sedative and antispasmodic.

ORDER 47.—*Campanulaceæ—Harebell Family.*

Type, $| \underline{S_{\overset{\frown}{5}} \quad P_{\overset{\frown}{5}} \quad St_{5} \quad C_{\overset{\frown}{3}}} |$

Herbs, flowers having a regular campanulate corolla. Æstivation valvate; stamens free from corolla, and mostly distinct; style having collecting hairs; capsule many-seeded, dehiscent; seeds numerous, albuminous.

Ex. *Campanula*.

Habitat, N. temperate regions.—Properties, unimportant.

Order 48.—*Ericaceæ—Heath Family.*

Type, $S_4 \quad \underline{|\,P_{\overset{\frown}{4}} \quad St_8\,|} \quad C_{\overset{\frown}{4}}$

Wiry shrubs. Leaves evergreen, exstipulate; calyx inferior persistent; stamens hypogynous; anthers dehiscing by pores; appendiculate many-celled ovary; seeds numerous, albuminous.

Ex. *Erica*.

Habitat, all temperate climates.—Properties, slightly astringent.

OFFICINAL.

Arctostaphylos Uva-Ursi (Bearberry),—leaves,—astringent and diuretic.

FORMERLY OFFICINAL.

Chimaphila umbellata, (Umbelled Winter-green),—herbaceous part,—tonic, astringent, diuretic.

Order 49.—*Aquifoliaceæ—Holly Family.*

Type, $S_{\overset{\frown}{4}} \quad \underline{|\,P_{4 \text{ or } \overset{\frown}{4}} \quad St_4\,|} \quad C_4$

Evergreen trees or shrubs. Leaves exstipulate; flowers small, sometimes declinous; corolla imbricate; ovary 2–6-celled, each containing one pendulous ovule; embryo small; seeds albuminous.

Ex. *Ilex*.

Habitat, widely scattered.—Properties, slightly tonic and astringent.

Order 50.—*Styracaceæ—Storax Family.*

Trees or shrubs. Ex. *Styrax*.

Habitat, warm regions.—Properties, stimulant.

OFFICINAL.

Liquidambar orientale (Storax)—liquid Balsam,—from *the bark*—stimulant and expectorant.

Styrax Benzoin (Benzoin),—balsam from bark, and Benzoic acid got by subliming it. Benzoin stimulant and expectorant; B. acid used in alkaline urine.

ORDER 51.—*Oleaceæ—Olive Family.*

Trees or shrubs. Ex. *Olea.*
Habitat, temperate climates.—Properties, demulcent.

OFFICINAL.

Olea Europæa (Olive),—fruit yielding oil, the oil forms hard soap with carbonate of soda, soft soap with carbonate of potash, and yields glycerine in the process,—demulcent, nutritive, slightly laxative.

Fraxinus rotundifolia }
„ ornus } (Manna); concrete juice (contains Mannite)—sweetening, laxative.

ORDER 52.—*Plantaginaceæ—Plantain Family.*

Type, $S_4 \quad \underline{|\; P_{\overset{\frown}{4}} \quad St_4 \;|} \quad C_{\overset{\frown}{2}}$

Herbaceous plants with underground stems; radicle leaves, ribbed; small flowers in spikes on scapes; calyx and corolla persistent; filaments long, anthers versatile; ovary simple, with spurious dissepiments; dehiscence circumscissile; seeds with a mucilaginous testa, albuminous. Ex. *Plantago.*
Habitat, generally diffused.—Properties, unimportant.

ORDER 53.—*Plumbaginaceæ—Thrift Family.*

Type, $S_{\overset{\frown}{5}} \quad \underline{|\; P_5 \quad St_5 \;|} \quad C_{\overset{\frown}{5}}$

Maritime or mountain herbs, usually with stems undeveloped and leaves clustered. Flowers regular; calyx tubular, plaited, and persistent; corolla salver-shaped; ovary one-celled; ovule solitary, pendulous, funiculus rising from base of cell; embryo large, with scanty albumen.
Ex. *Statice; Armeria.*
Habitat, some very widely diffused. — Properties, astringent.

ORDER 54.—*Primulaceæ—Primrose Family.*

Type, $S_5^{\frown} \quad \underline{\mid P_5^{\frown} \quad St_5 \mid} \quad C_5^{\frown}$

Herbs. Leaves simple; flowers regular and perfect; stamens equal in number to lobes of corolla, and opposite them; ovary usually superior, one-celled; placenta free central; seeds numerous, albuminous; style simple; stigma capitate; embryo transverse.

Ex. *Primula; Anagallis*

Habitat, N. temperate and subarctic regions.—Properties, some more or less irritant.

ORDER 55.—*Loganiaceæ.*

Herbs, shrubs, or trees. Really differ little from Rubiaceæ save in the free ovary.

Ex. *Strychnos; Spigelia.*

Habitat, tropical or subtropical regions.—Properties, all dangerous poisons.

OFFICINAL.

Strychnos nux vomica (Nux vomica). Seeds contain strychnine—tonic and nervine stimulant.

Faba St. Ignatii also yields strychnine. Spigelia is a dangerous poison.

ORDER 56.—*Apocynaceæ—Dog-bane Family.*

Type, $S_5^{\frown} \quad \underline{\mid P_5^{\frown} \quad St_5 \mid} \quad C_2^{\frown}$

Herbs, shrubs, or trees, with milky juice. Leaves usually opposite, exstipulate; flowers regular; corolla usually contorted; filaments distinct; anthers sometimes slightly connected; pollen granular; styles simple; ovules numerous; seeds albuminous.

Ex. *Sinca.*

Habitat, chiefly tropical.—Properties, often poisonous, juice yields caoutchouc.

ORDER 57.—*Gentianaceæ—Gentian Family.*

Type, $S_5^{\frown} \quad \underline{\mid P_5^{\frown} \quad St_5 \mid} \quad C_2^{\frown}$

Herbs, usually smooth, with colourless bitter juice. *Leaves* simple, exstipulate; flowers regular; calyx persistent; corolla usually convolute; stamens epipetalous; ovary one-celled, with parietal placentæ; capsule many-seeded; seeds albuminous. Ex. *Gentiana; Ophelia.*

Habitat, all parts of the world.—Properties, bitter tonic.

OFFICINAL.

Gentiana lutea (Gentian),—root,—tonic.

Ophelia chirata (Chiretta),—entire plant,—tonic.

ORDER 58.—*Convolvulaceæ—Bindweed Family.*

Type, $S_5 \quad \underline{\lvert\; P_{\overset{\frown}{5}} \qquad St_5 \;\rvert} \quad C_{\overset{\frown}{2}}$

Herbs, usually twining or trailing, often with milky juice. Leaves alternate; flowers regular; calyx imbricate; corolla contorted; ovary two-celled, sometimes with false partitions; embryo large and curved, albuminous; cotyledons foliaceous.

Ex. *Convolvulus; Exogonium.*

Habitat, mostly tropical.—Properties, mostly purgative.

OFFICINAL.

Convolvulus scammonia (Scammony),—root, gum-resin, and pure resin,—purgative.

Exogonium purga (Jalap),—root-tuber and resin of it,—purgative.

ORDER 59.—*Solanaceæ—Nightshade Family.*

Type, $S_{\overset{\frown}{5}} \quad \underline{\lvert\; P_{\overset{\frown}{5}} \qquad St_5 \;\rvert} \quad C_{\overset{\frown}{2}}$

Herbs, rarely shrubs, with watery juice. Leaves alternate; flowers usually regular; stamens equal in number to the lobes of the corolla; ovary usually two-celled; fruit capsular or baccate; seeds numerous, albuminous; embryo straight or curved. Ex. *Solanum; Atropa.*

Habitat, generally distributed.—Properties, mostly narcotic or narcotico-acrid.

OFFICINAL.

Solanum Dulcamara (Woody Nightshade), dried twigs, (alk., solania)—alterative.

Atropa Belladonna (Deadly Nightshade). Leaves and root (act. prin., atropia),—narcotic, and sedative.

Datura Stramonium (Thorn Apple). Leaves and seeds, (alk.-daturia),—sedative.

Hyoscyamus niger (Henbane). Leaves and twigs, (act. prin., alk.-hyoscyamia),—sedative.

Nicotiana Tabacum (Tobacco). Leaves, (act. prin., nicotina),—sedative.

Capsicum fastigiatum (Cayenne Pepper),—pods,—stimulant.

Most are dangerous poisons.

ORDER 60.—*Scrophulariaceæ—Figwort Family.*

Type, $S_5^{\frown} \quad \mid \underline{P_5^{\frown} \quad St_4} \mid \quad C_2^{\frown}$

Herbs, sometimes shrubs. Leaves alternate, opposite, or verticillate; flowers more or less irregular, sometimes labiate; corolla imbricate; stamens didynamous; ovary free, 2-celled; placentæ axile; seeds albuminous; embryo small. Ex. *Scrophularia; Digitalis.*

Habitat, universally diffused.—Properties, mostly dangerous, some very poisonous.

OFFICINAL.

Digitalis purpurea (Foxglove);—leaves (act. prin., digitaline),—sedative and diuretic.

ORDER 61.—*Boraginaceæ—Bugloss Family.*

Type, $S_5^{\frown} \quad \mid \underline{P_5^{\frown} \quad St_5} \mid \quad C_4^{\frown}$

Hairy, scentless herbs, with round stems. Leaves alternate; inflorescence scorpioid; flowers regular; corolla often with scales in the throat; stamens epipetalous; ovary 4-lobed; style gynobasic; seeds ex-albuminous. Ex. *Myosotis; Symphytum.*

Habitat, N. temperate regions.—Properties, mucilaginous.

ORDER 62.—*Labiatæ—Mint Family.*

Type, $S_5^{\frown} \quad \mid \underline{P_5^{\frown} \quad St_4} \mid \quad C_4^{\frown}$

Aromatic herbs with square stems and opposite leaves. Flowers irregular, labiate, in axillary cymes; calyx persistent; stamens didynamous; ovary free, deeply 4-lobed, separating into 4-achenes; style gynobasic; seeds erect, with little or no albumen.

Ex. *Mentha; Lavandula.*

Habitat, temperate climates.—Properties, aromatic.

OFFICINAL.

Rosmarinus officinalis (Rosemary),—oil distilled from flowering tops,—stimulant.

Lavandula vera (Lavender),—oil distilled from flowers,—stimulant.

Mentha piperita (Peppermint),—oil, and whole plant,—stimulant.

Mentha viridis (Spearmint), oil, and whole plant,—stimulant.

FORMERLY OFFICINAL.

Mentha Pulegium (Pennyroyal),—oil distilled from whole plant,—stimulant.

ORDER 63.—*Verbenaceæ—Vervain Family.*

An order closely allied to the Labiatæ, but distinguished by a terminal style and more coherent carpels.

Ex. *Verbena; Tectona.*

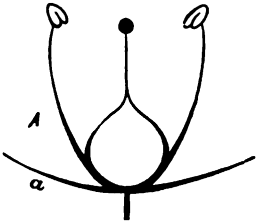
Habitat, temperate or tropical.—Properties, some valuable timber-trees. Tectona yields the teak-wood of commerce.

SUB-CLASS IV.

Monochlamydeæ.

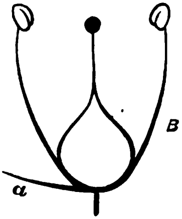
Dicotyledonous plants with a green or coloured calyx and no petals; with a green perianth of more than one whorl; with the floral envelopes reduced to one or more bract-like organs, or with them entirely absent.

FIG. 308.



A, Monochlamydeæ; *a*, Calyx.

FIG. 309.



B, Achlamydeæ; *a*, Bract.

This group, which is a very artificial one, partially consists of aberrant specimens of the orders already described.

ORDER 64.—*Polygonaceæ—Buckwheat Family.*

Type, $\lvert\, S_5^{\frown} \underline{\quad} P_0 \underline{\quad} St_6 \,\rvert \quad C_3^{\frown}$

Herbs. Leaves alternate, with ochreate stipules; flowers usually perfect; perianth more or less persistent; stamens hypogynous, rarely perigynous; ovary 1-celled; ovule solitary, erect; fruit, a nut; seed albuminous, inverted. Ex. *Polygonum; Rheum.*

Habitat, universally diffused.—Properties varied, some purgative.

OFFICINAL.

Rheum—? (Rhubarb-root),—tonic, astringent, purgative.

ORDER 65.—*Chenopodiaceæ—Goosefoot Family.*

Type, $\lvert\, \underline{S_5^{\frown} \quad P_0 \quad St_5} \,\rvert \quad C_2^{\frown}$

Herbs. Flowers small and bractlike; perianth free, imbricated; stamens equal to lobes of perianth in number, and inserted on them; ovary 1-celled and 1-seeded; embryo curved or spiral, sometimes without albumen. Ex. *Chenopodium; Beta.*

Habitat, dry waste places.—Properties, some valuable for food, as spinach, beet, &c.

ORDER 66.—*Lauraceæ—Laurel Family.*

Aromatic trees or shrubs.

Ex. *Laurus; Nectandra.*

Habitat, chiefly tropical.—Properties, aromatic, stimulant.

OFFICINAL.

Cinnamomum Zeylanicum (Cinnamon),—bark of twigs, and oil distilled from them,—stimulant.

Camphora officinarum (Camphor),—concrete volatile oil, sublimed from wood,—stimulant and sedative.

Sassafras officinale (Sassafras),—dried root,—stimulant and diaphoretic.

Nectandra Rodicæi (Bebeeru),—bark and alk. Beberia,—*tonic and febrifuge.*

FORMERLY OFFICINAL.

Laurus nobilis (Sweet Bay),—fruit,—slightly stimulant.

ORDER 67.—*Myristicaceæ—Nutmeg Family.*

Ex. *Myristica.*

Habitat, tropical.—Properties, aromatic and stimulant.

OFFICINAL.

Myristica officinalis (Nutmeg),—kernel of fruit, concrete expressed oil, and distilled volatile oil,—stimulant, aromatic.

ORDER 68.—*Thymelaceæ—Mezereon Family.*

$$\text{Type,}\quad \underline{S_{\widehat{4}}\quad P_0\quad St_8}\quad C_1$$

Shrubs with tough bark. Flowers perfect; perianth petaloid, free; ovary 1-celled; seed solitary, pendulous, exalbuminous. Ex. *Daphne; Lagetta.*

Habitat, in all parts of the world.—Properties, acrid.

OFFICINAL.

Daphne Mezereum (Mezereon) Daphne Laureola (Spurge Laurel)	Dried bark	Diaphoretic and alterative in small doses.

ORDER 69.—*Euphorbiaceæ—Spurge Family.*

Male	♂	S_3	P_0	St_{1-12}	C_0
Female	♀	S_3	P_0	St_0	$C_{\widehat{3}}$

Herbs, shrubs, or trees, with acrid milky juice. Flowers diclinous, sometimes in an involucre. Male flower with one or more stamens; female with superior ovary, several celled, and several seeded, with central column, separating when ripe; seeds albuminous, suspended. Ex. Croton; Ricinus.

Habitat, generally diffused.—Properties, acrid

OFFICINAL.

Croton Eleuteria (Cascarilla);—bark;—aromatic, tonic.

Croton Tiglium (Croton-oil); — oil expressed from seeds,—purgative, vesicant.

Ricinus communis (Castor-oil); — oil expressed from seeds,—purgative.

ORDER 70.—*Urticaceæ.—Nettle Family.*

Male	S_4	P_0	St_4	C_0
Female	S_4	P_0	St_0	C_1

Herbs, shrubs, or trees. Leaves alternate, stipulate; flowers monœcious or diœcious; perianth regular, free; ovary one or two-celled, one-seeded; stamens equal in number to the lobes of the calyx, and opposite them; radicle of embryo superior.

Ex. *Urtica; Cannabis.*

Habitat, generally diffused, some tropical.—Properties, very varied.

OFFICINAL.

Ficus Carica (Fig),—fruit,—sweetening, slight laxative.

Morus nigra (Mulberry,)—juice of the ripe fruit,—refrigerant and colouring agent.

Cannabis sativa (Indian Hemp),—flowering tops of female plant,—anodyne and antispasmodic.

Humulus Lupulus (Hop),—catkin of female plant,—sedative and tonic.

ORDER 71.—*Ulmaceæ—Elm Family.*

Type, $S_{\overset{\frown}{5}}$ P_0 St_5 $C_{\overset{\frown}{2}}$

Trees. Leaves alternate, stipulate; flowers perfect or polygamous; perianth free; stamens perigynous; ovary superior; fruit a samara or drupe; seeds suspended, with a scanty albumen; radicle of embryo superior.

Ex. *Celtis*, ovary one-celled; *Ulmus*, ovary two-celled.

Habitat, Northern regions.—Properties, timber trees.

OFFICINAL.

Ulmus campestris (Elm),—inner bark,—tonic and *astringent.*

ORDER 72.—*Platanaceæ—Plane Family.*

Trees with watery juice. Leaves lobed, alternate; stipules sheathing; flowers monœcious, naked; fruit clavate one-seeded nuts, in heads; seeds pendulous; albumen scanty; radicle inferior.

Ex. *Platanus.*

Habitat, Northern regions.—Properties, unimportant.

ORDER 73.—*Juglandaceæ—Walnut Family.*

Trees. Leaves alternate, pinnate, exstipulate; flowers monœcious; sterile flowers in catkins, stamens indefinite; fertile flowers, solitary, or in small clusters; ovary inferior, with one erect ovule; fruit a tryma; seed exalbuminous, cotyledons large, oily.

Ex. *Juglans.*

Chiefly North American.—Properties, furnish valuable timber.

ORDER 74.—*Cupuliferæ—Oak Family.*

Trees or shrubs. Leaves alternate, simple; stipules deciduous; flowers monœcious; the barren in catkins; the fertile, solitary or clustered, furnished with an involucre; ovary inferior, surmounted by limb of calyx; fruit one-celled and one-seeded, surrounded by the cup-like involucre; seeds exalbuminous; cotyledons large.

Ex. *Quercus; Corylus.*

Habitat, temperate climates.—Properties, astringent; valuable timber.

OFFICINAL.

Quercus pedunculata (Oak),—bark of small branches, —astringent.

Quercus infectoria (Gall-oak),—excrescences on twigs or galls, yielding tannic and gallic acids;—astringent.

ORDER 75.—*Betulaceæ—Birch Family.*

Trees or shrubs. Flowers monœcious, in catkins; ovary two-celled, two-ovuled; fruit one-celled, one-seeded; seeds pendulous, exalbuminous.

Ex. *Betula; Alnus.*

Habitat, cold and temperate climates.—Properties, tonic, astringent.

ORDER 76.—*Salicaceæ—Willow Family.*

Trees or shrubs. Flowers diœcious, in catkins, achlamydeous; ovary one-celled, many ovuled; fruit dehiscing by two valves; seeds downy, exalbuminous.

Ex. *Salix; Populus.*

Habitat, cold and temperate climates.—Properties, tonic.

FORMERLY OFFICINAL.

Salix caprea (Willow),—bark, yields salicine;—tonic.

ORDER 77.—*Piperaceæ—Pepper Family.*

Herbs or shrubs.

Ex. *Piper; Cubeba.*

Habitat, tropical.—Properties, aromatic and stimulant.

OFFICINAL.

Piper nigrum (Black Pepper),—unripe berries;—stimulant.

Cubeba officinalis (Cubebs),—fruit and oil distilled from it;—stimulant to urethra.

Artanthe elongata (Matico),—leaf;—styptic.

FORMERLY OFFICINAL.

Chavica Roxburghii (Piper Longum or Long-pepper)—fruit,—stimulant.

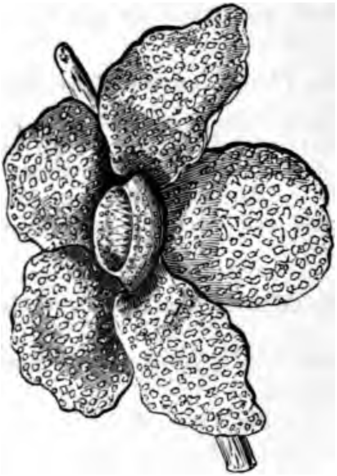
ORDER 78.—*Rafflesiaceæ.*

Fungoid parasites, without stems or peduncles; flowers solitary, sessile on trunks of trees.

Ex. *Rafflesia.*

Habitat, East Indies.—Properties, astringent and styptic.

FIG. 310.



Rafflesia Arnoldi, a Rhizogen, first found by Arnold (in remembrance of whom, and likewise of Sir Stamford Raffles, it was called the Rafflesia Arnoldi). It measures a full yard across, the petals being twelve inches long and a foot apart from each other.

ORDER 79.—*Aristolochiaceæ—Birth-wort Family.*

Herbaceous or climbing shrubby plants.

EX. *Aristolochia.*

Habitat, generally diffused.—Properties, stimulant.

OFFICINAL.

Aristolochia Serpentaria (Serpentary),—dried root;—stimulant and tonic.

CLASS I.

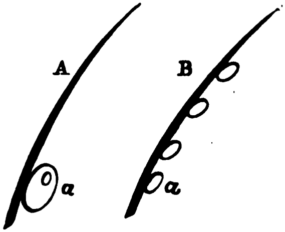
DICOTYLEDONES.

DIVISION II.

Gymnospermia.

Exogens, with ovules and seeds naked; (that is, not enclosed in an ovary.) Ovules fertilized by the direct application of the pollen; carpel scaly, leafy, or absent.

FIG. 311.



Male. Female.

Diagram of Gymnospermia.

ORDER 80.—*Coniferæ—Pine Family.*

Trees or shrubs with resinous juice. Leaves usually evergreen, scattered or fascicled, and needle-shaped; flowers monœcious or diœcious; female flowers in cones. Ovules, two or more on the surface of each carpel; fruit a woody cone, or a galbulus; seeds albuminous; cotyledons, two or many.

Ex. *Pinus; Juniperus.*

Habitat, all parts of the world.—Properties, very varied; most yield timber.

SUB-ORDERS.

1. Abietinæ; ovules inverted, pollen oval.
2. Cupressinæ; ovules erect, pollen spherical.

OFFICINAL.

Pinus palustris, „ tæda, „ pinaster,	Pines yielding turpentine, which when distilled yields *oil of turpentine* and *resin*. Stimulant, rubefacient, anthelmintic, astringent, diuretic. The two last yield frankincense.

Abies balsamea yields a turpentine known as Canada balsam.

Abies excelsa yields a turpentine known as Burgundy pitch.

Pinus sylvestris, &c., yields, by destructive distillation, tar (Pix liquida).

Juniperus communis (Juniper). Unripe fruit yields, by distillation, oil of juniper,—stimulant and diuretic.

Juniperus Sabina (Savine)—tops, which yield, by distillation, oil of savine,—stimulant and emmenagogue.

Larix,—oil, and bark—stimulant.

CLASS II.

MONOCOTYLEDONES, OR ENDOGENÆ.

Flowering plants, with stems composed of parenchyma not separable into pith and bark, containing isolated fibro-vascular bundles of the definite kind diffused through it. Leaves often sheathing at the base, and parallel-veined; flowers with 3-merous symmetry; embryo with one cotyledon only; radicle never developed.

SUB-CLASS I.

Spadicifloræ.

Flowers on a spadix, naked, or enclosed in a spathe.

FIG. 312.

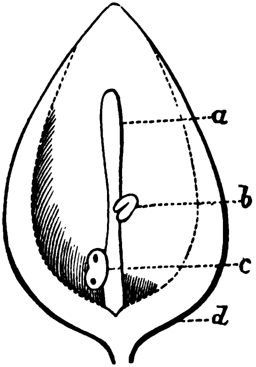


Diagram of Spadicifloræ.

a, Spadix; *b*, Male flowers; *c*, Female flowers; *d*, Spathe.

ORDER 81.—*Typhaceæ—Bulrush Family.*

Marsh herbs. Leaves linear sessile; flowers monœcious on a spadix, or in heads; no true perianth; ovary one-celled; seed solitary, albuminous.

Ex. *Typha; Sparganium.*

Habitat, mostly northern.—Properties, unimportant.

ORDER 82.—*Araceæ—Arum Family.*

Herbs or shrubs, with acrid juice. Veins of leaves sometimes partially reticulated; monœcious flowers on a spadix, usually in a spathe; perianth absent; fruit succulent; seeds usually albuminous.

Ex. *Arum; Calla.*

Habitat, mostly tropical.—Properties, more or less acrid.

ORDER 83.—*Lemnaceæ—Duckweed Family.*

Floating plants. Roots rising from a more or less circular frond; monœcious flowers in a spathe, rising from the margin of the frond; perianth 0; fruit a utricle; seeds albuminous. Ex. *Lemna; Pistia.*

Habitat, temperate and tropical regions.—Properties, unimportant.

SUB-CLASS II.

Petaloideæ.

Monocotyledons with a double perianth, both whorls

FIG. 313.

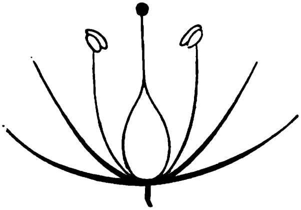


Diagram of Petaloideæ.

sepaloid, both petaloid, or the outer green, the inner coloured; flowers usually perfect.

ORDER 84.—*Smilaceæ—Sarsaparilla Family.*

Herbs or climbing shrubs. Leaves reticulate, stalked.

Ex. *Smilax; Paris.*

Habitat, temperate regions.—Properties, alterative.

OFFICINAL.

Smilax officinalis (Sarsaparilla)—root; alterative.

These orders, including Araceæ, with certain others, are sometimes classed as a separate group under the title of DICTYOGENS, characterised by having endogenous stems and reticulate leaves.

ORDER 85.—*Liliaceæ—Lily Family.*

Type, S_3 P_3 St_6 $C_{\widehat{3}}$

Herbs. Leaves parallel-veined, sessile, sometimes sheathing; flowers regular and perfect; perianth free, coloured; anthers introrse; style 1; fruit usually capsular; seeds albuminous.

Ex. *Lilium; Scilla.*

Habitat, widely distributed.—Properties, very varied.

OFFICINAL.

Urginea Scilla (Squill),—bulb;—stimulant, expectorant, and diaphoretic.

Aloe vulgaris (Aloe),—inspissated juice;—purgative.

ORDER 86.—*Melanthaceæ—Colchicum Family.*

Herbs with bulbs, corms, or swollen roots. Flowers regular, symmetry 3-merous; perianth more or less free; anthers extrorse; fruit capsular; seeds albuminous; embryo minute.

Ex. *Colchicum; Veratrum.*

Habitat, widely diffused. — Properties, dangerous irritants.

OFFICINAL.

Asagræa officinalis (Sabadilla),—dried fruit yields alk. Veratria,—a powerful purgative and local irritant, &c.

Colchicum autumnale (Colchicum);—corm and seed (yielding Colchicia),—purgative, used in gout.

FORMERLY OFFICINAL.

Veratrum album (White Hellebore), yielding veratria, and producing the same effects as Sabadilla.

ORDER 87.—*Juncaceæ—Rush Family.*

Type, $S_3 \quad P_3 \quad St_6 \quad C_{\overset{\frown}{3}}$

Sedgy or grass-like herbs. Flowers regular, sometimes glumaceous, in heads; perianth inferior, persistent; anthers introrse; fruit capsular; embryo minute in horny or fleshy albumen. Ex. *Juncus.*

Habitat, cold and temperate regions.—Properties, of little importance.

ORDER 88.—*Orchidaceæ—Orchid Family.*

Type, $\underbrace{S_{\overset{\frown}{3}} \quad P_3 \quad \underbrace{St_1 \quad C_{\overset{\frown}{3}}}}$

Herbs. Flowers irregular; perianth adherent to the ovary; calyx more or less coherent; corolla often twisted, so that the posterior part becomes anterior (the labellum); stamens gynandrous; pollen coherent, forming pollinia; ovary one-celled; placenta parietal; seeds numerous.

Ex. *Orchis; Vanilla.*

Habitat, temperate and tropical climates.—Properties, of no great importance.

ORDER 89.—*Zingiberaceæ—Ginger Family.*

Aromatic herbaceous plants, with a creeping rhizome.

Ex. *Zingiber; Curcuma.*

Habitat, tropical regions.—Properties, aromatic and astringent.

OFFICINAL.

Zingiber officinale (Ginger),—dried rhizome,—aromatic and stimulant.

Elettaria cardamomum (Cardamom),—seeds,—aromatic and astringent.

Curcuma longa (Turmeric),—rhizome,—colouring and test agent, stimulant.

ORDER 90.—*Marantaceæ—Arrow-root Family.*

Closely allied to Zingiberaceæ, but want the aroma.
Ex. *Maranta; Canna.*
Habitat, tropical.—Properties, nutritive.

FORMERLY OFFICINAL.

Maranta arundinacea (Arrow-root),—rhizome,—demulcent and nutritive.

ORDER 91.—*Amaryllidaceæ.*

Bulbous and scape-bearing plants. Flowers regular, or nearly so; perianth superior, sometimes with a corona; stamens 6; anthers introrse; fruit a capsule or berry; seeds albuminous; radicle next to hilum.
Ex. *Amaryllis; Narcissus.*
Habitat, chiefly Cape of Good Hope.—Properties, some poisonous.

ORDER 92.—*Iridaceæ—Iris Family.*

Perennial herbs, with underground stems. Leaves equitant; flowers regular or irregular; perianth superior, petaloid; stamens 3; anthers extrorse; stigma often petaloid; fruit capsular; seeds albuminous.
Ex. *Iris; Crocus.*
Habitat, chiefly Cape of Good Hope.—Properties, some acrid.

OFFICINAL.

Crocus sativa (Saffron),—stigma and part of style;—colouring agent, slight stimulant.

ORDER 93.—*Alismaceæ.*

Marsh herbs, with scape-like flowering stems; flowers perfect, or monœcious; perianth double; ovaries separating into nuts; embryo straight or curved, without albumen. Ex. *Alisma; Butomus.*
Habitat, marshy ground in all parts.—Properties, unimportant.

SUB-ORDERS.

1. Juncagineæ. Perianth scaly; embryo straight.
2. Alismeæ. Inner part of perianth coloured; ovules solitary or twin; embryo curved.
3. Butomeæ. Inner part of perianth coloured; ovules numerous, all over the interior of the carpels; embryo curved.

ORDER 94.—*Naiadaceæ—Pond-weed Family.*

Cellular aquatic plants, with jointed stems. Leaves stipulate; flowers small, usually diclinous, naked, or with a scale-like perianth; ovary 1-celled, and 1-ovuled; seed exalbuminous; embryo straight or curved.

Ex. *Zostera; Potamogeton.*

Habitat, universally diffused.—Properties, of no importance.

SUB-CLASS III.

Glumiferæ.

Monocotyledons, with the flowers in spikelets; perianth *scaly* or bristly; leaves mostly linear, with large sheaths, *tubular* or slit; seeds albuminous.

FIG. 314.

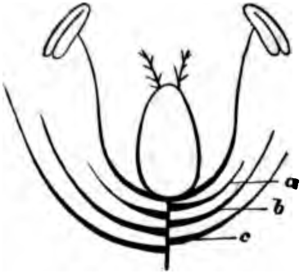


Diagram of Glumiferæ.
a, Lodiculæ. *b*, Paleæ. *c*, Glumes.

ORDER 95.—*Graminaceæ—Grass Family.*

Type, $S_{2\,\&\,1}$ P_2 St_3 C_1

Mostly herbs, rarely shrubs. Stems round, jointed, and usually hollow; leaves alternate; leaf-sheath split, with a ligule at the base of the lamina; flowers composed of a whorl (2) of bracts called glumes; calyx in the form of scales (paleæ), the inner double; the corolla of 2 or 3 hypogynous scales (lodiculæ), sometimes wanting; stamens hypogynous; anthers versatile; ovary superior, 1-celled; ovule solitary; stigma hairy; fruit a caryopsis; seed albuminous.

Ex. *Hordeum; Triticum.*

Habitat, universally distributed.—Properties, very varied.

OFFICINAL.

Triticum vulgare (Wheat),—flour, bread, and starch;—nutritive and demulcent.

Hordeum distichum (Barley),—seeds decorticated;—demulcent.

Secale cereale as Secale cornutum	(Ergot)	seeds modified by a fungus; excito-motor to muscles of vessels and uterus.

Saccharum officinarum (Sugar),—purified juice;—sweetening agent.

Contains the plants most valuable to man.

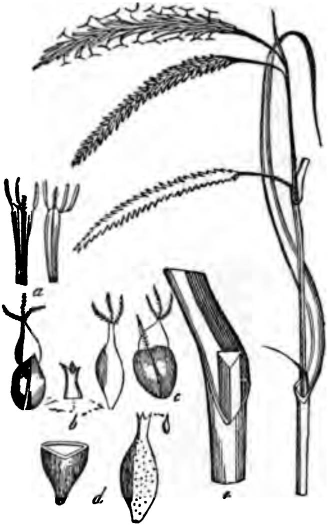
ORDER 96.—*Cyperaceæ—Sedge Family.*

Type, S_0 P_0 St_3 P_1

Grassy or rush-like herbs. Stems solid, unjointed, often angular; leaf-sheath entire; flowers in spikes, perfect, or unisexual, rising from glumaceous bracts; perianth generally absent, or, if present, as a kind of tube, scales or bristles; stamens hypogynous; ovary 1-celled; fruit indehiscent; seeds albuminous.

Ex. *Cyperus; Carex.*

FIG. 315.



Carex pendula.—Upper part of the culm, showing the superior position of the staminiferous spikes and the inferior of the pistilliferous ones, the linear venation of the leaves, the entire sheaths, and the absence of ligulæ. *a*. Staminiferous flowers, with erect innate anthers. *b*. Pistilliferous flowers enlarged, to show the ovary, style, the three plumose stigmata, and the keeled bracteæ. *c*. The double scale at the base of the fertile flower. *d*. The fruit enlarged, and cut transversely.

SUB-KINGDOM II.

CRYPTOGAMIA—FLOWERLESS PLANTS.

CLASS III.

Acotyledones. No embryo or seed lobes.

Propagated by spores containing no embryo, and having no distinction of parts, and therefore no cotyledons; stems present or absent, when present, growing at the summit only; leaves, when present, with forked venation; no true flowers.

SUB-CLASS I.

Acrogenæ.

Acotyledons, with stems and leaves distinguishable, and possessing stomata.

ORDER 97.—*Filices—Ferns.*

Herbs with an underground, or trees with an aërial, stem. Leaves or fronds simple or compound, usually with circinate venation; fructification of sporangia commonly collected in sori usually in the forks of the veins, on the under surface or at the margins of the leaves, naked or covered by an indusium.

Habitat, moist and mild regions.—Properties, of no great importance.

SUB-ORDERS.

1. Polypodiaceæ. Fronds circinate; sporangia more or less annulate, with perpendicular ring, on the surface of the fronds, or in spikes.
Ex. *Polypodium.*
2. Danæaceæ. Fronds circinate; sporangia exannulate.
Ex. *Danæa.*

3. Ophioglossaceæ. Fronds not circinate; sporangia exannulate. Ex. *Ophioglossum.*

OFFICINAL.

Aspidium Filix mas (Male Fern),—rhizome and extract;—anthelmintic.

ORDER 98.—*Equisetaceæ—Horsetail Family.*

Heads with striated, jointed, fistular stems,—simple or with whorled branches—rising from slender rhizomes. Scales surrounding the stems at the joints, looked upon by some as leaves; stems otherwise leafless; fructification in cone-like masses at the extremity of the stem, consisting of peltate scales bearing sporangia which dehisce by longitudinal fissures on their lower surfaces; spores with four club-shaped, hygrometric filaments, called elaters. Ex. *Equisetum.*

Habitat, marshy spots in most parts of the world.—Properties, contain much silica.

ORDER 99.—*Marsileaceæ—Pepperwort Family.*

Aquatic herbs with floating or creeping stems. Leaves stalked or sessile, circinate; fructification at the bases of the leaves; antheridia and pistillidia in the same, or in separate sporangia.

Ex. *Pilularia; Marsilea.*

Habitat, mostly in temperate climates.—Properties, of no importance.

ORDER 100.—*Lycopodiaceæ—Club-moss Family.*

Herbs with creeping, bifurcating stems, or aquatic with corm-like stems. Leaves usually small and imbricated; fructification in the axils of leaves, or immersed in their substance, sometimes in spikes; sporangia containing only small antheridian spores, or one set containing these, and another containing large ovulary spores. Ex. *Lycopodium; Isoetes.*

Habitat, universally diffused.—Properties, some are dangerous.

ORDER 101.—*Musci—Moss Family.*

Land or water plants with erect or creeping stems. Leaves minute cellular; fructification of antheridia and archegonia, either on the same or on different plants. Antheridia are more or less rounded, or cylindrical sacs, enclosing cells (Zoothecæ), which each contain a reproductive filament (phytozoon). The archegonia are flask-shaped, after fertilization producing solitary sporangia, containing spores without elaters. The sporangium is supported on a stalk (seta), and at first is covered by a hood (calyptra), beneath which is an operculum or lid. When dehiscing, the mouth of the sac breaks into teeth (peristome), either four or a multiple of four in number.

Habitat, generally diffused, but most abundant in temperate regions.—Properties, unimportant.

SUB-ORDERS.

1. Bryaceæ—Urn Mosses; sporangia dehiscing transversely, or irregularly.
Ex. *Bryum.*

2. Andræaceæ—Split Mosses; sporangia splitting into four valves, connected at the top by the persistent operculum. Ex. *Andræa.*

ORDER 102.—*Hepaticaceæ—Liverwort Family.*

Small cellular plants with creeping stem and imbricated leaves, or frond-like thallus. Fructification of antheridia and archegonia in the substance of the thallus, sessile or stalked; sporangia sometimes open by valves, and spores have elaters.

Habitat, generally diffused, mostly in damp tropical regions.—Properties, unimportant.

SUB-ORDERS.

1. Jungermanniaceæ (Scale Mosses). Sporangia opening by four valves, and spores with elaters.
Ex. *Jungermannia.*

2. Marchantiaceæ (True Liverworts). Sporangia bursting irregularly; spores with elaters.
Ex. *Marchantia.*

3. Ricciaceæ (Crystal-worts). Sporangia without valves; no elaters. Ex. *Riccia.*

ORDER 103.—*Characeæ.*

Water-plants with a distinct stem. Branches in whorls, sometimes coated with carbonate of lime.

Ex. *Chara; Nitella.*

Habitat, stagnant water, mostly in temperate climates. —Properties, some very fœtid.

SUB-CLASS II.

Thallogenæ.

Acotyledons, without any distinction between stem and leaves; no stomata.

ORDER 104.—*Lichenes—Lichens.*

Cellular plants with a more or less crustaceous thallus, sometimes parasitic; fructification either in the substance or on the surface of the thallus; reproduction (vegetative) by gonidia produced in the thallus, or by spores produced in sacs termed asci, and spermagones containing spermatia.

Ex. *Parmelia; Cetraria.*

Habitat, universally diffused.—Properties, yield dyes, food, and medicine.

OFFICINAL.

Cetraria Islandica (Iceland moss)—thallus,—nutritive and tonic.

Roccella tinctoria }
Lecanora tartarea } (Litmus), — thallus, — colouring agent.

ORDER 105.—*Fungi—Mushroom Family.*

Cellular plants with a spawn (Mycelium) through which they are nourished. Fructifying in the air; living on, or in, decaying organic substances. Fructification varied.

Ex. *Agaricus; Torula; Mucor.*

Habitat, all parts of the world.—Properties, some poisonous, some edible.

The following distinctions are given by Professor Bentley:—

Edible Mushrooms.	*Poisonous Mushrooms.*
1. Grow solitary in dry, airy places.	1. Grow in clusters in woods, and dark damp spots.
2. Generally white or brownish.	2. Usually brightly coloured.
3. Flesh compact and brittle.	3. Flesh tough, soft, and watery.
4. Do not change colour when cut and exposed to the air.	4. Become brown, green, or blue, when cut and exposed to the air.
5. Juice watery.	5. Juice often milky.
6. Odour agreeable.	6. Odour usually strong and unpleasant.
7. Taste not bitter, acrid, salt, or astringent.	7. Taste acrid, acid, astringent, salt, or bitter.

☞ When doubtful, steep them in vinegar, and boil them well before using.

ORDER 106.—*Algæ—Sea-weed Family.*

Cellular plants growing in water and moist places. Thallus brown, red, or green; of large size or microscopic; fructification varied.

Habitat, universally diffused.—Properties, some used as food.

SUB-ORDERS.

1. Melanospermeæ, Fucoideæ, or Olive-coloured sea-weeds. Marine plants. Thallus multicellular, of an olive-green or olive-brown colour; reproduced by zoospores, spores, and antheridia.

Ex. *Fucus; Laminaria.*

2. Rhodospermeæ, Florideæ, or Rose-coloured sea-weeds. Marine plants. Thallus multicellular, red or purple; reproduced by spores, antheridia, and tetraspores. Ex. *Chondrus; Corallina.*

3. Chlorospermeæ, Confervoideæ, or Green sea-weeds. Marine or fresh-water plants. Unicellular or multicellular

sea-weeds, usually green, rarely red; reproduced by spores, from conjugation or impregnation, and by zoospores.

Ex. *Ulva; Conferva.*

4. Diatomaceæ, Brittle-worts. Microscopic unicellular plants, isolated or combined; forms regular; covering membranous or siliceous; reproduced by spores, zoospores, and division.

Section 1.—Diatomeæ. Fresh water and marine; covering siliceous.

Ex. *Navicula.*

Section 2.—Desmidieæ. Fresh-water plants of a green colour; covering without silica.

Ex. *Desmidium.*

5. Volvocineæ. Microscopic bodies floating freely in water, and swimming by cilia.

Ex. *Volvox.*

PART V.

GEOGRAPHICAL AND GEOLOGICAL BOTANY.

SECTION I.

GEOGRAPHICAL BOTANY.

As all plants are not equally distributed in space and in time, the object of this department of Botany is to find out the laws by which their distribution is regulated. Though dissimilar in their facts, the principles to be applied for the elucidation of these facts in the two departments are closely allied—more so, indeed, than would appear to the uninitiated.

Influences bearing upon the Spread of Plants.—Of all the influences bearing upon the spread of plants, by far the most important is that of climate. Various constituents go to make up what is termed climate—viz., heat, moisture, light, atmospheric disturbances, &c., all of which are of importance when considering the distribution of plants. Every species of plant can bear a certain variation in *temperature,* but if this be exceeded in either direction the plant dies from excess of cold in the one case, from excessive heat in the other. Were land and water equally distributed, and were the earth's surface perfectly level, it might be expected that every place under the same parallel of latitude would have the same temperature. Such, however, is not the case, and lines of equal temperature (Isothermal lines) do not, therefore, coincide with the parallels of latitude. In geographical botany, moreover, the lines of average temperature are really of less importance than those of highest and lowest temperature, both annually and *diurnally.* Besides the horizontal lines of demarcation, plants have certain limits vertically, for an ascent of a few hundred feet makes as great a difference as many miles measured along the surface of the earth; so that plants inhabiting the arctic zone may be found growing within the tropics, though at a great height above the level of the sea.

Moisture and Drought depend, in a great measure, on temperature, and are therefore agents secondary to it. As the ocean is the great source of moisture, those parts adjoining it will have a damper climate than those more inland. Again, as mountains are the chief means of abstracting vapour from the atmosphere, those countries which possess high mountains will be better supplied with water than flat districts in the same latitude. The direction of winds is also of some importance as to the diffusion of moisture, for winds that have blown over an extensive tract of land, will contain but little moisture compared with those blowing directly off the sea.

The distribution of plants is also affected by minor, though still important influences, such as *marine currents*, in conveying fruits and seeds from one place to another. *Rivers* act in the same manner, more especially those flowing parallel with the equator. *Winds* carry the lighter seeds of the Phanerogamia and the spores of the Cryptogamia. *Icebergs* convey earth and seeds to distant regions; and *migrating animals* carry with them seeds in their coats or stomachs. Man also is an important agent in the distribution of species, carrying with him those which are beneficial, and destroying those that are noxious. Man also modifies, to some extent, the habitat of species, altering the climate by cutting down forests, and draining swamps, from which cause many plants have been exterminated and new ones substituted.

Distribution of Plants.—When individual species are examined, it will be found that they vary extremely as to the area of their distribution, some being almost cosmopolitan, whilst others are strictly local. There is, however, in every case, a region where the species is most abundant, and the specimens are best developed: this is termed their *centre* distribution, and the space in which they occur, is called their *area of distribution.* It often happens that the area is interrupted, as in the case of the Scottish, Scandinavian, and Swiss mountain tops, which appear to possess nearly identical floras. This is accounted for by supposing that at a former period these mountain tops were directly connected by land or by water, and that every part, except these mountain tops, was covered by water during what is termed the "Glacial Period," is now universally admitted. When the same species does not occur in two countries having a similar climate, it often happens that one is represented by another closely allied to it, as in the case of American and European violets, Cape and British heaths, and so on. As to the mode in which species originate, no subject is more canvassed at the present day, and any discussion of it would be very much out of place here.

Botanical Regions.—Various attempts have been made to map out the globe into regions characterised by a peculiar vegetation. Of these the two most important are *Meyen's* and *Schouw's.*

Meyen divided the globe into *zones,* bounded by parallels of latitude, but as variations of temperature depend on more than the mere latitude of a place, isothermal lines are preferable as boundaries. His first zone was the *equatorial,* characterised by the extreme luxuriance of its vegetation, on either side lay the *tropical* and *subtropical* zones, bounded in turn by the *warmer* and *cooler* temperate zones, beyond which came the *subarctic* and *arctic,* with finally the *polar* zones.

Schouw's *regions* are characterised, not by temperature but by vegetation; unfortunately, they do not exactly correspond with the latest information, as much has been learnt since his arrangement was made public. He divides the surface of the earth into twenty-five regions, according to the following principles: 1st. At least one-half of the species of a region must be peculiar to it. 2nd. One-fourth part of the genera either peculiar to the region, or attain their maximum in it. And 3rd. The orders either peculiar to, or at their maximum in it.

Altitude.—The vertical disposition of plants, as already mentioned, closely corresponds with their horizontal distribution. Humboldt divided the regions observed on high tropical mountains into tropical, temperate, and frigid, corresponding in their products with the same zones on the surface of the globe. Meyen attempted a more exact classification, but has not been entirely successful. His first region is that of Palms and *Bananas,* corresponding with his equatorial zone; his second, that of Tree Ferns and Figs with his tropical; his third, that of Laurels and Myrtles with his subtropical; his fourth, or region of Evergreens, with his warmer temperate zone; his fifth, that of Deciduous trees, with his colder temperate zone; his sixth, that of Coniferæ, with his subarctic; his seventh, or Rhododendron region, with his arctic zone; and his region of Alpine herbs, with his polar zone. The British flora contains plants of several types. Thus plants of what is termed the British type are common to the whole country, and seem to have their head-quarters in it. There are also the English, Germanic, Atlantic, Scottish, and Highland types, each represented by species whose centres appear to be located in or near the places named. The only two vertical regions observed are termed the Arctic and Agrarian, but each contains several subdivisions.

SECTION II.

PALÆONTOLOGICAL BOTANY.

As Geographical Botany deals with the distribution of plants in space, so Geological or Palæontological Botany treats of their distribution in time, and scanty though the materials still are, for obtaining an insight into the former, facts are still more deficient with regard to the latter.

Nature of Vegetable Fossils.—Plants occur as *fossils* in various conditions, sometimes as *petrifactions*, where the natural tissue of the plant has been superseded by some mineral substance, as silica, lime, or pyrites. Again they occur in the condition of *coal*, either as anthracite, lignite, or peat, and very often only as *casts*, nothing being left in the rock save an impression. There is much more difficulty in the way of studying the botanical than the zoological part of Palæontology, as it is but rare that the characteristic portions of plants are found, and microscropical structure can do little more than indicate the great division of the kingdom to which the vegetable belongs. Besides this, those plants which occur most abundantly in the older formations are of a texture which it is difficult to preserve in a recognisable state, and it is only fair to conclude that many of them have entirely disappeared. Nevertheless, it must be conceded that as much attention has not been given by geologists to Botany as to Zoology.

GEOLOGICAL DISTRIBUTION OF PLANTS.

Palæozoic.—In the elder palæozoic rocks few plants occur, and those that are found are mostly Cryptogams, Thallogens, and Acrogens, with a few Gymnosperms. During the coal period, vegetation was very abundant, though the number of known species is inconsiderable; they were Cryptogams, more especially Ferns and Lycopods, some as Asterophyllites, and Sigillariæ of doubtful place, with a few Gymnosperms, and some doubtful Monocotyledons.

Mesozoic.—During the mesozoic epoch, Cryptogams lose their old supremacy to be replaced by Conifers and Cycads, while in the chalk, Dicotyledons make their appearance for the first time.

Tertiary.—The tertiary formations are characterised and distinguished from all preceding groups by the marked preponderance of Dicotyledons and Monocotyledons over Cryptogams. During the miocene period palms appear to have been very abundant, but they disappear during the pliocene, whilst in pleistocene deposits but few vegetables occur, those few being Coniferæ.

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